Commonwealth of Virginia

Tributary Restoration Strategy for the Rappahannock River and Northern Neck Coastal Basins

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Assisted by
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Rappahannock Conservation Council
Rappahannock Technical Review Committee
Virginia Department of Conservation and Recreation
Virginia Department of Forestry
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Virginia Coastal Program

Executive Overview

A Plan for Restoring Water Quality and Living Resources

Virginia's *Tributary Restoration Strategy for the Rappahannock River and Northern Neck Coastal Basins* is a plan to restore water quality and living resources in Rappahannock River, its tributaries, and the coastal waterways of Northern Neck. The *Strategy* sets forth nutrient and sediment reduction goals for these waters, identifies management practices to partly meet these goals, and offers recommendations for continued water quality improvements.

Although the *Strategy* sets forth a comprehensive program to reduce nutrient and sediment loads and improve water quality, a number of follow-up actions and "next steps" are planned to ensure that the *Strategy* initiative is a success. These include the production of a *Rappahannock Strategy Technical Appendix,* which will detail regional loadings and water quality information, and the development of any implementation publications that are needed to assist and promote this effort. These documents are included by reference as part of the *Strategy*.

Water Quality Problems in the Rappahannock River Basin

Extensive water quality monitoring in Rappahannock River and its tributaries has shown that high nutrient and sediment loads have led to water quality problems in many areas of the basin. These problems have degraded the diversity and abundance of fisheries and aquatic life. In the western basin, these problems include: "impaired waters" (waters not meeting a water quality standard), and chronic erosion, siltation and bank instability. In the eastern basin, these problems include: nutrient over enrichment and algal blooms, low levels of dissolved oxygen, diminished submerged aquatic grasses, and high levels of suspended solids. The Northern Neck coastal waters suffer similar problems, including algal blooms and low dissolved oxygen.

A Cooperative Approach to River Restoration

The *Strategy* was developed to address these problems. It was constructed using a cooperative process that emphasized local needs and viewpoints. Members of Rappahannock River Basin Commission, Rappahannock Conservation Council and Rappahannock Technical Committee worked diligently to represent their constituents and to achieve consensus on effective and balanced solutions. This cooperation led to strong support for establishing water quality restoration goals and identifying needed implementation practices.

Water Quality and Habitat Restoration Goals

Restoration goals were established for improving water quality and habitat conditions by the year 2010. These goals were based on modeling results from the Bay water quality computer model, which simulates how different levels of nutrient and sediment reductions could improve water quality, particularly the amount of dissolved oxygen in the water column and the health of submerged grasses. The two principal restoration goals that were established are:

- to reduce by approximately 50% (actual model prediction is 45%) the annual volume of anoxic water (water that has no dissolved oxygen) in Rappahannock River, and
- to increase by approximately 50% (52% prediction) the density of submerged grasses.

Nutrient and Sediment Reduction Goals

The Bay water quality model projects that reaching these restoration goals will require the following nutrient and sediment reductions in the basin (compared to 1985 total loads):

- Nitrogen - 33% reduction (target nitrogen load of 6,949,000 lbs/year)
- Phosphorus - 29% reduction (target phosphorus load of 663,000 lbs/year)
- Sediment - 20% reduction (target sediment load of 289,000 tons/year).

Decision Based on Water Quality and Cost/Benefit Considerations

Other options were considered. However, *Strategy* participants determined that lower reduction goals would not sufficiently improve water quality in Rappahannock River, and that greater reduction goals would be too costly for the benefits they achieve. In particular, as implementation levels approach "limit of technology" (all currently available practices), the cost/pound of further reductions increases dramatically.

A Vision for Rappahannock River Restoration

The Rappahannock River Basin Commission, and many local governments, adopted a long-term "Vision for Rappahannock River Restoration." This Vision is to eventually eliminate anoxic conditions in Rappahannock River under most rainfall years. The model projects that achieving this Vision would require a very high level of nutrient reduction in the Rappahannock basin, as well as in upper Chesapeake Bay basins, whose nitrogen loads affect Rappahannock River water quality. It is not yet known how these high levels of reduction would be achieved.

Additional Tributary Strategy Goals

To address chronic erosion and stream bank instability in the western Rappahannock basin, an additional goal of the *Strategy* is to promote Governor Gilmore's proposed Conservation Reserve Enhancement Program and to:

- Implement CREP in the Rappahannock basin by reestablishing 4,604 acres of riparian buffers (equal to 491 stream miles at a width of 75 feet) and 456 acres of wetlands.

Finally, The *Rappahannock Tributary Strategy* also identifies the following goal, which is mostly applicable to the western portion of the Rappahannock basin:

- Remove all stream segments from the 303(d) Impaired Waters list which are impaired as a result of localized pollutant loads in the basin.

Projected Water Quality Benefits

In the western basin, implementing the Conservation Reserve Enhancement Program will reduce nutrient and sediment loads and will improve stream habitat. The riparian restoration, wetland restoration and erosion control practices identified in the *Strategy* will benefit local water quality as well as shoreline property owners. Local water quality improvements will also be achieved through reduction of pollutants that have led to violations in water quality standards.

In lower Rappahannock River, a 45% reduction in the seasonal volume of anoxic water means that substantial habitat will become fully or partly available to aquatic life. In years when dissolved oxygen levels are very low, this translates to an increased volume (averaged over 92 days) of river habitat that is 40 feet high, 650 feet wide and 27 miles long. In years when oxygen levels are higher, this means an average increased volume of river habitat that is 20 feet high, 325 feet wide and 5.5 miles long. A 50% increase in density of submerged aquatic grass beds means that most beds will be healthy enough to withstand seasonal anomalies in water quality conditions. These grass beds will further increase water clarity, improving conditions for establishment of nearby grass beds and development of very productive shallow water habitat.

These improvements will lead to other benefits in the Rappahannock food web and ecosystem. For example, reduced sediments and increased dissolved oxygen will improve the river's benthic (river bottom) communities, which filter sediments, process nutrients and provide food for fish. Improved grasses will also provide nutrient uptake and food for forage species.

Management Practices and Implementation Actions

Farmers, wastewater treatment plant owners, local officials, conservation groups and citizens in the Rappahannock basin have taken many steps to reduce nutrient and sediment loads. Due to various natural factors in the basin, these steps have been insufficient to reverse declines in water quality. However, they provide a valuable foundation for the *Strategy* and serve as building blocks for continued actions to reduce nutrients and sediments.

Implementation practices were identified in cooperation with stakeholders in the basin. For agricultural nonpoint sources, agricultural staff in the basin estimated annual implementation rates for best management practices, under the conditions of fully available cost-share funding and needed program enhancements. These rates were projected to the year 2010 to calculate total nutrient and sediment reductions. For point sources, treatment plant operators set forth the scenario that plants in the Rappahannock basin over 1 million gallons per day flow would strive to install nutrient removal technology, under the condition of fully available cost-share funding.

A Gap in Meeting the Nitrogen Reduction Goal

The resulting point and nonpoint source nutrient and sediment reductions were combined with projections of increased point source nutrient loads, from population growth, to estimate total loads at year 2010. The practices currently identified in the *Strategy* meet the sediment and phosphorus goals by 2010. However, these practices will not meet the nitrogen goal. Therefore, further work will be done to find additional practices and programs for nitrogen reduction.

Effect of Potential Regulatory Programs on the *Rappahannock Strategy*

The *Strategy* is a voluntary program. However, Federal regulatory programs have been proposed which affect *Strategy* goals and implementation practices. These include: the listing of portions of Chesapeake Bay and tidal Rappahannock River as "impaired waters;" the regulation of animal feeding operations (livestock agriculture); and the development of nutrient criteria.

Many *Strategy* participants believe that these regulatory proposals add uncertainty to the process and will delay efforts to restore Rappahannock River. Wastewater treatment plant owners, dairy farmers and other major nutrient sources may not undertake costly nutrient controls knowing that these controls could later prove insufficient to meet regulations. *Strategy* participants generally feel that the various levels of government have the responsibility to better coordinate these programs in order to add efficiency and consistency to implementation efforts.

Projected Costs

Costs for nutrient and sediment reduction practices will be paid for using a combination of state, local and individual funds. The state cost-share portions of these actions taken over the next eleven years (in 1998 dollars) is estimated to be: $8,791,000 for point sources (assuming 50% cost-share level); and $39,366,000 for nonpoint sources (assuming 75% cost-share, including any needed staff and technical resources). These figures are planning-level estimates.

The estimated annual average state cost for implementing the identified nonpoint source management practices is $3,579,000. This figure may increase beyond 2005, as it becomes necessary to implement more costly (per pound of nutrient or sediment removed) management practices in order to maintain, or increase, the annual rates of nitrogen reduction. The costs for implementing Virginia's Conservation Reserve Enhancement Program in the Rappahannock basin are not included in the *Strategy*, because they are part of a separate budgetary initiative.

For point sources, it is expected that the four treatment facilities in the basin that have already installed nutrient removal systems will make reimbursement requests immediately for $4,048,000 state cost share. One major facility is expected to upgrade to nutrient removal technology in the next one or two years, with a state cost-share request of $2,631,000.

Recommendations for Enhanced Restoration

Strategy participants provided ideas and recommendations on how to enhance water quality restoration and increase implementation rates beyond current *Strategy* levels. These recommendations included specific program or funding changes, and directions for continued planning or study. Many recommendations pertained to expanding public involvement and interest in the Rappahannock restoration effort, and tracking and monitoring *Strategy* progress.

Agricultural field staff in the basin recommended program and funding changes that will be needed to achieve, or expand, the annual implementation rates of agricultural management practices identified in the *Strategy*. These recommendations are listed in the *Strategy*.

Other recommendations developed through the *Strategy* process include:

- Produce a *Rappahannock Strategy Technical Appendix* that provides stakeholders with a clearer picture of water quality problems, trends and possible solutions in the Rappahannock River basin.
- Develop any needed implementation publications that will assist or promote the *Strategy*.
- Locate and account for any best management practices (agricultural and urban) that exist in the basin but have not been tracked through the state's tracking program.

- Work with local officials to identify any opportunities for reductions from urban and suburban nonpoint sources, and to minimize further increases resulting from growth.
- Develop an urban nutrient management program for the Rappahannock basin.
- Develop a comprehensive *water resource management plan* for the Rappahannock basin.
- Control pollutants (nutrients and pathogens) from individual septic tank systems.
- Provide incentive payments to wastewater treatment plants to achieve concentrations of nitrogen in effluent below 8 mg/l.
- Encourage research and testing of new point source nutrient removal technologies.
- Promote and support small watershed projects/groups.
- Promote and support Virginia's Oyster Heritage Program.
- Ensure that sediment reductions remain a key issue throughout implementation.
- Improve monitoring of "bedload" sediment levels.
- Improve monitoring of dissolved oxygen levels in lower Rappahannock River.
- Improve monitoring and analysis of water quality conditions in the western portion of the Rappahannock basin.
- Improve monitoring and analysis of water quality conditions in Great Wicomico River and Northern Neck coastal creeks.
- Explore new avenues for involving more citizens and organizations in the effort to restore Rappahannock River.
- Set aside a percentage (e.g., 3-5%) of Water Quality Improvement Fund money to assist with educational efforts that will expand future implementation rates.
- Develop and promote nutrient trading opportunities in the Rappahannock basin to take advantage of cost-effective solutions to nutrient reduction.

<u>Follow-up Actions and Reevaluations</u>

The *Strategy* sets up a number of continued processes and reevaluations along the way to achieving *Strategy* goals. A program reevaluation will be conducted in 2002 which will focus on assessing whether all needed program enhancements or modifications are in place. A technical evaluation will be conducted in 2005 which will focus on assessing progress and additional opportunities toward meeting the nutrient and sediment reduction goals. Both of these processes will be supported by annual progress reports on reaching milestones; and both will address ways to improve targeting of nitrogen reductions. Other objectives for these reevaluations include:

- Determine whether recommended program changes have been put in place that will achieve the management practices identified in the *Strategy*.
- Continue to assess ways to improve procedures and eligibility for agricultural cost-share.
- Identify any other barriers to effective implementation and recommend solutions.
- Identify ways to expand public involvement in the Rappahannock restoration effort.
- Identify other programs, practices and opportunities for achieving and enhancing sediment and nutrient (particularly nitrogen) reductions.
- Evaluate effects and relationships of other programs (including regulatory programs) on the *Strategy* effort.

- Track implementation rates and levels of nutrient and sediment reductions.
- Identify additional types or areas of monitoring, as needed, to improve tracking.
- Monitor and assess improvements in water quality and living resources as a result of *Strategy* implementation.
- Coordinate monitoring/modeling activities and data.
- Revise the nitrogen goal or deadline if determined to be unattainable.

The *Rappahannock Strategy* must remain a dynamic process; and this document will continue to be improved as new information and technologies become available and as the results of the scheduled reevaluations become available. Updates to the *Strategy* will be accomplished each year, as needed, through the Secretary of Natural Resources' Annual Report to the General Assembly on the Development and Implementation of Nutrient Reduction Strategies for Virginia's Tributaries to the Chesapeake Bay, produced in November of each year.

Acknowledgments

It is difficult to recognize the many people who have played invaluable roles in the development of the *Rappahannock Strategy* and in the larger effort to restore the Rappahannock River and Northern Neck coastal basins. The following generally lists some of the major groups and individuals involved with these initiatives.

It is first important to acknowledge the many farmers in the Rappahannock basin who are good stewards and who have already undertaken many conservation efforts. As a group, these farmers are dedicated to conserving land and water resources. Without their efforts, there would have been no foundation upon which to build a *Rappahannock Strategy*.

Local officials, soil and water conservation district staff, extension agents, wastewater treatment plant operators and conservation groups in Rappahannock River and Northern Neck coastal basins also have undertaken many conservation actions to reduce nutrient and sediment loads to Rappahannock River. Local officials throughout the basin have been strong supporters of the *Strategy* and have already implemented numerous conservation programs, including effective Chesapeake Bay Preservation Act programs in the eastern portion of the basin. Also, a number of small watershed groups have formed across the basin to promote public knowledge and interest in the value of streams, rivers and creeks in the Rappahannock basin.

This *Strategy* would not have been possible if it were not for the local and state elected officials who serve on the Rappahannock River Basin Commission, and the locally elected soil and water conservation district directors who serve on the Rappahannock Conservation Council. These officials have devoted countless hours over the past two and one-half years to providing input and guidance to *Strategy* development.

<u>Rappahannock River Basin Commission</u>

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William Frazier, John Marshall SWCD
Lloyd B. Mundie, Three Rivers SWCD
Mac Saphir, Hanover-Caroline SWCD
Debbie Fisher, Staff - Rappahannock Watershed Coordinator

No less important to this effort was the work of the state and federal agency staff, university scientists, district directors, wastewater treatment operators, conservation group representatives and local officials who continue to serve on the Rappahannock Technical Committee. The work of this committee has been dedicated, insightful and practical.

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These constructive, cooperative efforts are the hallmark of the *Rappahannock Strategy*. The guiding principle of the *Strategy* is finding ways to empower the stewardship ethic that already exists in the Rappahannock basin, rather than promoting government direction and control. The first implementation priority of the *Strategy* is to build upon this stewardship ethic and to ensure that local officials, citizens and conservation groups have the tools available to fully implement the conservation initiatives they have undertaken or plan to undertake.

Collin Powers
Rappahannock Strategy Team Leader
November, 1999

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Commonwealth of Virginia
Tributary Restoration Strategy for the Rappahannock River and Northern Neck Coastal Basins

I. Introduction

The Rappahannock River and its unique system of tributary rivers, streams, creeks and nearby coastal embayments of Northern Neck represent a natural resource of great value to the citizens of Virginia. The Rapidan River, Corrotoman River, Great Wicomico River, Cat Point Creek, Hazel River, Mountain Run, Thornton River, Totuskey Creek, Urbanna Creek, Robinson River, Marsh Run, Hoskins Creek, Piscataway Creek and other waterways are part of this river system (figure 1). Their worth includes not only their bounty, beauty and recreational value, but also their connection to the history, tradition and quality of lands within the Rappahannock basin. This connection has fostered a common esteem and appreciation for Rappahannock River that reaches from its headwaters to the mouth.

This document is *Virginia's Tributary Restoration Strategy for the Rappahannock River and Northern Neck Coastal Basins.* Its purpose is to set in motion a number of implementation and funding actions that will help restore water quality and living resources in Rappahannock River and Northern Neck coastal waters over the coming decade. It is designed also to initiate further discussions and cooperative efforts that will bolster this restoration effort.

This report describes the rationale, approach, process, goal and implementation plan of the *Strategy*. It does not include all technical aspects of the *Strategy*. Some of these issues, such as descriptions of the status of living resources in the Rappahannock River, were addressed in Rappahannock Tributary Strategy Status Report produced in July, 1998, and Virginia Tributary Basin Water Quality Technical Synthesis, produced in September, 1998. A description of the water quality monitoring that supports the *Strategy* effort is provided in Water Quality Monitoring in the Rappahannock River Basin, produced in 1997 by the Virginia Dept. Of Environmental Quality. Please contact the Chesapeake Bay Office of VDEQ (804-698-4310) if you would like to see a copy of one or more of these reports.

Over the past three years, participants in the *Strategy* process have dedicated a significant amount of time and effort to reaching consensus on goals and implementation practices for restoring Rappahannock River, its tributaries and the coastal waterways of the Northern Neck.

During this process, there was strong support for establishing "robust" nutrient and sediment reduction goals that would lead to major improvements in water quality and living resources. This support was strong despite the challenge of implementing sufficient nutrient reduction practices to achieve those goals. In its current form, the *Strategy* does not identify sufficient nutrient management practices to achieve the nitrogen reduction goal by 2010. Because of this shortfall, additional planning must be conducted over the next two to five years to close the nitrogen gap. These planning efforts will follow the same cooperative approach that was used to develop the *Strategy*.

For this and other reasons, the *Strategy* is presented as a dynamic document that can be enhanced and improved in response to feedback from stakeholders and citizens. Following the same cooperative approach used to build the *Strategy*, this document is intended to foster local solutions to water quality problems and to allow for new and innovative approaches to restoring living resources in the Rappahannock River and Northern Neck coastal basins.

II. Description of Rappahannock River and Northern Neck Coastal Basins

Rappahannock Basin

The Rappahannock River basin (see Figure 1) is located in northeastern Virginia between the Blue Ridge Mountains and Chesapeake Bay. The basin is bordered by the Potomac River basin to the north and west, and the York and James river basins to the south. The basin extends across the Appalachian, Piedmont and Coastal Plain physiographic provinces and covers an area of 2,715 square miles. This represents 6.8% of Virginia's total area and 4% of the area of the Chesapeake Bay watershed. The basin is 184 miles in length. Topography in the basin varies from steep in the western portion to flat in the eastern portion.

Land use in the basin is approximately 55% forested, 38% agriculture and 7% urban. Of all Virginia's tributaries to the Chesapeake Bay, the Rappahannock basin has the highest percentage of agricultural land use above the Fall Line (the Fall Line is the boundary between the Piedmont and Coastal Plain provinces and generally represents the upstream limit of tides).

Population in the Rappahannock basin grew from 151,000 in 1985 to around 228,000 in 1996, with growth occurring mostly around the City of Fredericksburg. Fredericksburg lies within the basin as do all or portions of 15 counties. The city and counties that are wholly or partially located in the Rappahannock basin include:

Upper region:	Culpeper, Fauquier, Greene, Madison, Orange and Rappahannock counties
Central region:	City of Fredericksburg and Spotsylvania and Stafford counties
Lower region:	Caroline, Essex, King George, Lancaster, Middlesex, Richmond and Westmoreland counties

Seven soil and water conservation districts share responsibility for agricultural technical assistance in the basin and for implemented agricultural BMP cost-share funds. These are:

- Culpeper SWCD;
- Hanover/Caroline SWCD;
- John Marshall SWCD;
- Northern Neck SWCD;
- Tidewater SWCD;
- Three Rivers SWCD; and
- Tri-County/City SWCD.

There are 2,616 miles of rivers and streams, 690 acres of lakes and 127 square miles of tidal estuaries in the Rappahannock basin. The headwaters lie in Rappahannock and Fauquier counties and the river flows to the southeast, entering Chesapeake Bay between Lancaster and Middlesex counties. The Rappahannock is dammed near the Fall Line by Embry Dam. Its major tributaries are Rapidan River, Robinson River, Hazel River, Thornton River, Mountain Run, Cat Point Creek, Piscataway Creek and Corrotoman River.

The basin includes 26 hydrologic units, delineated for purposes of watershed management and water quality planning. When these hydrologic units are differentiated into freshwater and estuarine portions, there are 33 water bodies designated. The nonpoint source pollution potential assessment performed by the Department of Conservation and Recreation (part of the 1998 305(b) report) resulted in the following rankings of the 33 water bodies:

- Eleven have a “high” potential for pollution from agricultural land uses;
- Eleven have a “high” potential for pollution from animal operations;
- Seven have a “high” potential for pollution from forest land use activities;
- Three have a “high” potential for pollution from urban land use; and
- Seven are listed by the state as being in the top 100 high priority watersheds for overall potential for nonpoint source pollution.

Northern Neck Coastal Basins

The Northern Neck coastal basins lie on the eastern tip of the Northern Neck peninsula, between the Potomac and Rappahannock river basins, and flow directly into the Chesapeake Bay. They are in the Coastal Plain province and cover an area of 130 square miles. This represents less than 0.4% of the area of Virginia and less than 0.2% of the Chesapeake Bay watershed. The topography of the area is flat. Land use is 64% forested, 30% agriculture and 6% urban. The area makes up 12% of Lancaster County and 49% of Northumberland County.

Tributaries that comprise the Northern Neck coastal basins include Great Wicomico River, Cockrell Creek, Mill Creek, Dividing Creek, Indian Creek, Dymer Creek, Tabbs Creek and Antipoison Creek. These waterways cover an area of 5.7 square miles.

III. Water Quality Problems in Rappahannock River and Northern Neck Coastal Basins

Overview of Water Quality Problems

Over the past twenty-five years, the Chesapeake Bay and its tributaries have been the focus of intensive environmental and ecological study. To understand the complex interactions between the Bay and its living resources, sophisticated computer models have been developed. These studies, which have been verified by years of water quality monitoring in the Rappahannock River and the entire Bay, have shown that nutrient over-enrichment is the most widespread and impactive water quality problem facing the Bay and its tributaries.

Though long considered one of the cleanest rivers on the east coast, recent studies indicate that the Rappahannock River suffers from significant degradations in water quality. It is currently considered the most degraded of Virginia's three lower Chesapeake Bay tributaries from a biological standpoint. These degradations have been identified through a vast array of water quality monitoring that is conducted by state agencies, universities and citizen groups. These degradations occur throughout the Rappahannock basin in a variety of forms, including:

- Impaired stream segments, mostly in the western portion of the basin;
- Chronic erosion, siltation and bank instability, mostly in the western portion;
- Low levels of dissolved oxygen in the eastern portion;
- Diminished acreage and health of submerged aquatic grasses in the eastern portion; and
- Impacts on fisheries (diversity and abundance) and aquatic life throughout the river basin.

During March of 1998, fifty of the top scientists in the Mid-Atlantic region who study water quality and aquatic living resources were convened at the Virginia Institute of Marine Science to bring together their combined research and knowledge of the status and trends of the Rappahannock, York and James rivers. These scientists confirmed that the Rappahannock River has recently suffered severe water quality degradations and that these problems have been caused by increased loadings of nutrients and sediments, exacerbated by recent high-flow rainfall years in the upper portion of the basin.

As algae populations have increased in the lower Rappahannock, they block light from reaching underwater grasses. After these algae die and sink to the bottom, the natural process of their decay robs the water of oxygen, essential for fish, shellfish and other aquatic organisms. These problems exists in the lower Rappahannock River where underwater grasses have declined significantly, and where severe hypoxia (very low dissolved oxygen) and anoxia (no dissolved oxygen) exist throughout the summer months each year, affecting numerous species that are commercially valuable or that serve important roles in the aquatic food web, such as benthic invertebrates.

The volume of anoxic water in the Rappahannock River during the summer months of each year is approximately three times greater than the combined volume of anoxic water in all of Virginia's portion of the Chesapeake Bay and other Bay tributaries, including the James and York rivers (see Figure 2).

High concentrations of sediments from nonpoint sources, and other suspended solids in the water column of the Rappahannock River, also have been shown to degrade living resources. In particular, these sediment loads impact zooplankton and submerged aquatic vegetation, which are important food and habitat, respectively, for many commercial and recreational fisheries.

The loads stemming from the Northern Neck coastal basins, such as the Great Wicomico River, are addressed in the *Rappahannock Strategy* because these loads affect the Rappahannock River as a result of currents in the Bay. These smaller systems, particularly the Great Wicomico, have also been the focus of more intensive monitoring, over the past two years, conducted by scientists from the Virginia Institute of Marine Science; and similar water quality problems have been identified in these waterways as well. However, further study is needed to better understand the nutrient effects, water quality problems and living resource status for these waterways.

The capacity of the Rappahannock to support living resources, including historically valuable fisheries, is seriously affected by high loadings of nutrients (nitrogen and phosphorus) and sediments. Excess nutrients in the basin have led to increased algae populations, which can adversely affect fish, oysters, crabs, underwater grasses and other aquatic life. In the Rappahannock basin, these nutrients come mostly (> 90%) from nonpoint sources, including surface runoff from farms, residential lands and other urban areas. Less than 10% of the nutrient load in the basin originates from point sources (wastewater treatment plants).

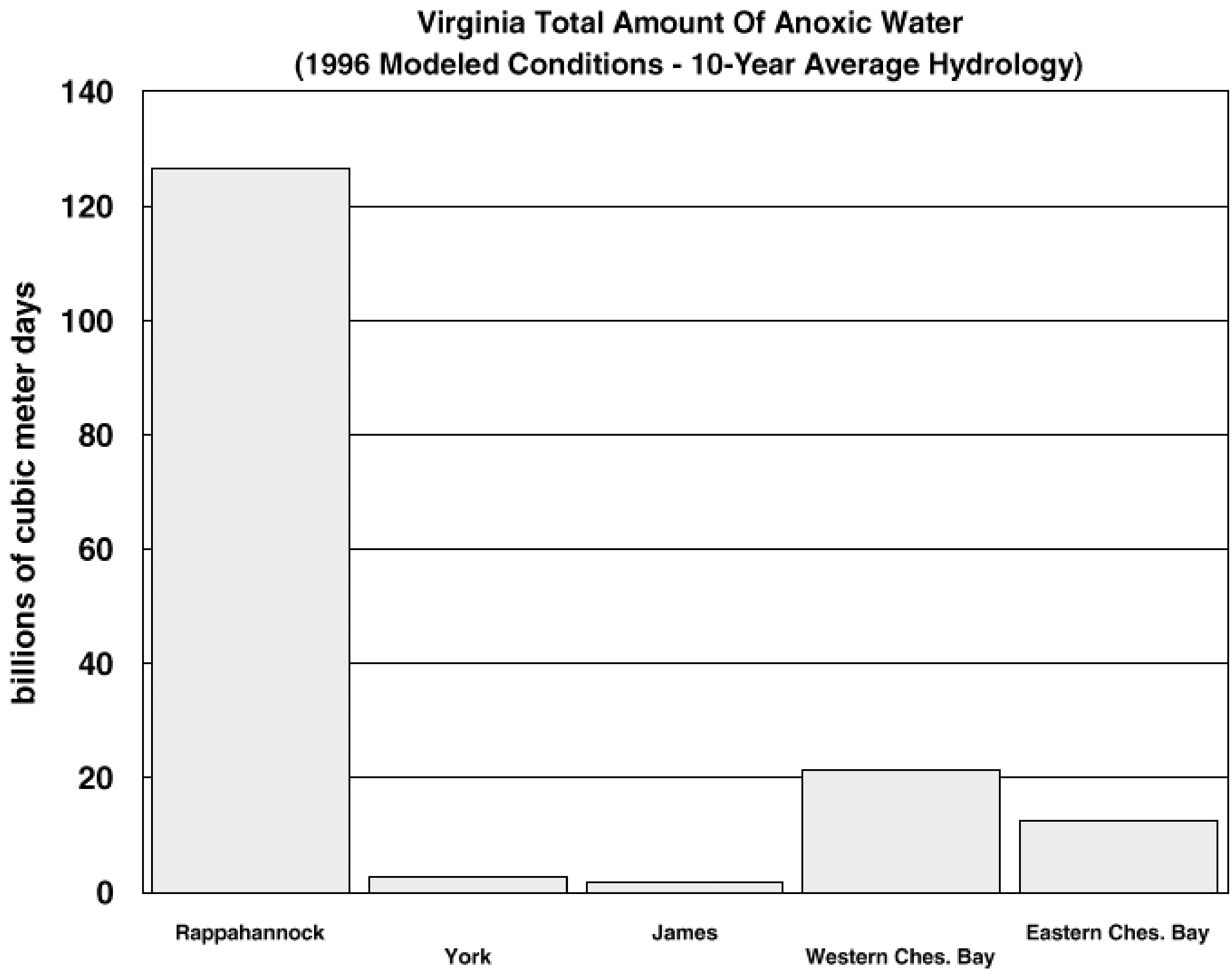
Nutrient and Sediment Loading Trends

Watershed Model Estimates and Flow-Averaged Estimates

Estimates of nutrient and sediment loads by the Chesapeake Bay Program Watershed Model, and flow-adjusted trend analyses by the USGS (based on Fall Line monitoring), are designed to provide data that is unaffected by yearly changes in rainfall. These estimates allow us to evaluate trends in nutrient loadings and the potential effect of management actions.

Based on data for land use, point source loads and implementation of agricultural BMPs, the Watershed Model estimates that nitrogen loads in the upper Rappahannock basin between 1985 and 1996 have been reduced by 6% and phosphorus loads have been reduced by 16% (assuming average rainfall). To compare these estimates to monitored loading rates (from the upper basin), the USGS measures river flow and constituent concentrations at the Fall Line and develops load data that are normalized to standard rainfall and river flow. Based on these flow-adjusted estimates, the trends for the upper basin between 1985 and 1997 show:

- decreasing concentrations of TN (estimated 38% reduction, with range of 28%-46%);



Virginia Total Amount Of Anoxic Water
(1996 Modeled Conditions - 10-Year Average Hydrology)
billions of cubic meter days
140
120
100
80
60
40
20
0
Rappahannock
York
James
Western Ches. Bay
Eastern Ches. Bay

- decreasing concentrations of TP (estimated 51% reduction, with range of 34%-64%); and
- decreasing concentrations of TSS (estimated 62% reduction, with range of 42%-75%).

But the upper Rappahannock basin still puts forth a higher yield of nutrients and sediments (load/acre) than any of Virginia's other Chesapeake Bay tributary basins.

The differences between estimated reductions for the upper basin by the Watershed Model and the flow-adjusted reductions calculated from the monitoring data may result, in part, from over-compensation by the flow-adjustment formula. In addition, it is likely that the number of BMPs that are voluntarily implemented (and therefore not accounted for in the Watershed Model) by farmers in the basin is very high. Also, point sources in the basin may be achieving greater nutrient reductions than current projections.

One of the most important messages to be learned from these data is that the types of agricultural management practices that have been implemented over the past twelve years in the upper Rappahannock basin have been extremely effective and should guide future efforts.

For the Rappahannock basin below the Fall Line, the Bay Program Watershed Model estimates that TN loads between 1985 and 1996 have been reduced by 16% and TP loads have been reduced by 36% (assuming average rainfall). There are no flow-adjusted monitoring data for below the Fall Line, as there are for the upper basin, because nonpoint loadings of nutrients and sediments enter the estuary from innumerable locations in the lower basin.

Actual Loading Trends from Above the Fall Line

Although constituent loads entering the Rappahannock estuary from above the Fall Line have been theoretically reduced (average rainfall conditions) between 1985 and 1996, the trends for actual loads of TN, TP and TSS coming from the upper Rappahannock basin have increased over these years due to above average rainfall and nonpoint source loadings. The sharpest trend increase is for TP, followed by TSS and then TN (which showed only a slight increasing trend).

These higher loadings have occurred despite implementation of point and nonpoint source nutrient and sediment controls in the basin between 1985 and 1996. Estimated (by Bay Program Watershed model) reductions in nitrogen, phosphorus and sediment loads to the river, assuming normal rainfall, have resulted from:

- Implementation of farming best management practices (BMPs);
- Implementation of local nonpoint source programs such as Chesapeake Bay Preservation Area programs;
- Installation of nutrient removal at wastewater treatment plants; and
- The ban on the use of phosphates in detergent.

One problem for the Rappahannock basin is that rainfall has exceeded normal levels in recent years, and this has increased actual nutrient and sediment loads from nonpoint sources. The disparity between management actions in the basin, and conditions in the river, is due in part to these higher nonpoint source loads from the occurrence of strong storm events and high rainfall years, particularly in the upper basin since 1993.

The impact of high rainfall is worsened by physical characteristics of the basin. Steep slopes in the upper basin make soil and nutrients susceptible to erosion and transport from storm events. USGS monitoring data show that the Rappahannock basin above the Fall Line has the highest yield (load/unit area) of total nitrogen, total phosphorus and total suspended solids of all the Bay tributary basins in Virginia (Rappahannock, York, and James). At the mouth of the Rappahannock, there is a sill and trench (depth change of greater than 20 feet) that restrict the flow of bottom water from Chesapeake Bay into the river. This creates a higher residence time for nutrients, BOD (biological oxygen demand) and oxygen-poor water due to poor flushing. This in turn has led to localized algal blooms and hypoxia (low levels of oxygen) and anoxia (no oxygen) in the bottom waters of the middle and lower estuary during summer months.

Status and Trends for Water Quality Indicators in the Tidal Rappahannock

Status and trends for nutrient and sediment loads (discussed above) provide valuable measures of the loading levels of pollutants that potentially reach the estuary, due to the effects of land use changes and management actions. However, the true measures of what the estuary sees in terms of ecological effects are the status and trends for concentrations of nutrients, sediments and other water quality parameters in the estuary itself. Status and trends for actual concentrations in the estuary can vary substantially from the status and trends for estimated loads. As previously noted, high rainfall can increase nonpoint source loadings, even though nutrient and sediment controls have been implemented. In addition, physical, chemical and biological factors in the estuary itself can affect concentrations of these constituents, and their impacts on the ecosystem.

The following discussion of water quality indicators in the Rappahannock basin use broad evaluation terms such as “good” and “bad.” Standards for these terms were developed throughout the Chesapeake Bay, relative to a number of river systems that are highly degraded. Therefore, the characterization “good” holds little relevance to the conditions that would be expected to maintain Rappahannock River in a healthy and productive state.

The current *status* of a few water quality indicators in the tidal portion of the Rappahannock (the estuary) remain “good,” such as total nitrogen (TN), algal levels and phytoplankton community health, certain others are currently “poor,” such as water clarity and total suspended solids (TSS) in the middle estuary, and dissolved oxygen in the lower estuary.

Trends for water quality in Rappahannock River are also mixed (good and bad signs), but certain significant degradations have occurred. There are improving trends in TN and algal levels in the estuary. However, there are degrading trends in many key indicators of water quality and living resource conditions, including total phosphorus (TP), dissolved oxygen (DO) in the lower estuary, bloom producing algae, cyanobacteria, diatoms, zooplankton in the lower estuary, benthic communities in the middle estuary, SAV, fish diversity and fish abundance. The 1998 draft 303(d) report by DEQ increased the number of impaired river segments in the Rappahannock basin from six in 1996 (total of 36.00 miles) to fourteen (total of 60.29 river miles and 0.06 square miles of the estuary). Impaired segments are found in all three regions of the river basin.

Synopsis of Water Quality Status and Trends in the Rappahannock Estuary

- Status of nitrogen good with some decreasing trends (which is good);
- Status of phosphorus good with generally increasing trends (bad);
- Chlorophyll *a* status good throughout the tributary with decreasing trends (good);
- Secchi disk (water clarity) poor to fair status, no significant trends detected;
- Total suspended solids fair to good, few trends in mid and down stream;
- Dissolved oxygen fair to good - lower portions some decreasing trends (bad)

Although the status of most parameters was good, there were only limited improvements in some water quality parameters and degradations in others. Expanded discussion of these status and trends are provided below for the most important parameters. They include references to established habitat criteria for growth and survival of submerged aquatic vegetation (SAV).

Nitrogen

Status for total nitrogen (TN) and dissolved inorganic nitrogen (DIN) was good at all segments and SAV habitat requirements for DIN were met in all regions that have an established habitat requirement. Improvements in TN were limited to a decreasing trend in the upper estuary, where surface and bottom observed concentrations were down 18% from 1985-1986 levels. There was a season-specific decreasing TN trend in the tidal fresh and downstream. There were no trends in TN near the mouth of the river, except for autumn decreases. No improving trends in DIN were detected below the Fall Line, with spring levels elevated everywhere in the estuary.

Phosphorus

Status of total phosphorus and dissolved inorganic phosphorus (DIP) was fair to good in all regions with the SAV habitat requirements for DIP being met or marginally met in all regions. Total phosphorus (TP) concentration trends were increasing throughout the estuary reflecting increases in actual loads from above the fall line due to increasing river flows since 1991. The below fall line decreases in point source total phosphorus loads were overwhelmed by increases in nonpoint source loads. Trends in DIP were not significant throughout the river.

Algae

Despite seasonally high peaks in the spring, the status of algae concentrations (measured as chlorophyll *a*) are relatively low, and the SAV requirement for algae levels is met in all regions of the river. This was due primarily to light limiting the growth of algae everywhere in the river. Decreasing algae concentrations were found in tidal fresh and mesohaline regions. However, there is no evidence that algal declines are due to declines in nitrogen loads. Rather increasingly poor water clarity seems to be the reason for the recent declining trend in algae concentrations. Given the N:P ratio in this river, the system would probably be phosphorus-limited if it were not light-limited. Chlorophyll *a* does not appear to follow any trends in nutrients or total suspended solids. The flushing effect of higher flows could, in part, account for observed decreases in chlorophyll *a*.

Suspended Solids

The status of total suspended solids ranged from fair to poor. The Rappahannock estuary is severely light limited. Except near the mouth and in the Corrotoman River, TSS and Secchi fail habitat requirements for SAV. Because loads and nutrient concentrations are going up, one could assume that TSS is also increasing. However, few trends in TSS were detected. Improvements in suspended solids will be required before any improvements in water clarity can be expected.

Water Clarity

Water clarity (measured as Secchi depth) requirement for SAV growth to 1 meter depth failed in most of the river, except in the lower mesohaline region and the Corrotoman River. Although no statistically significant trends in water clarity were detected, time series plots of water clarity showed a general decrease during the last two to five years in all regions. As with the other Virginia tidal tributaries, water clarity should be a priority since poor water clarity will adversely affect the success of restoration SAV to these rivers.

Dissolved Oxygen

There were no significant trends in bottom dissolved oxygen in the mainstem of Rappahannock River. In Corrotoman River, bottom dissolved oxygen concentrations were observed to be very low. In the Rappahannock, higher flows result in lower bottom dissolved oxygen in the lower estuary due to increased stratification in the water column and loadings of more nutrients to the river. Based on recent studies, hypoxia (<3 mg/L DO) in the Rappahannock is linearly related to total nitrogen loading. Increases in total nitrogen loading will likely result in increased hypoxia. Conversely, decreasing total nitrogen loads will result in reduced hypoxia.

Hypoxia is primarily an internal problem of the Rappahannock, caused by two-layer flow and relatively slow flushing. Conditions in the lower estuary may be exacerbated by influx of low-oxygen water from the Bay, but most likely are caused by primary production within the estuary itself near the area of the hypoxia. The usual scenario is that the spring bloom feeds the hypoxia through the summer. The bloom is caused by available nutrients and low grazing pressure. The hypothesis for the Rappahannock is that in spring, biologic control of algal levels is from the bottom-up (level of available nutrients); in summer, it is both bottom up and top down (grazing by zooplankton and other species). Hypoxia is typically broken up after August.

Table 1: Rappahannock River ambient annual surface medians (1994-96).

	TN mg/L	DIN mg/L	TP mg/L	DIP mg/L	CHL μg/L	SECCHI m	TSS mg/L	BDO* mg/L
Tidal Fresh	0.923	0.493	0.075	.0156	5	0.6	22	7
Oligohaline	0.764	0.366	0.094	.0120	6	0.4	32	7
Upper Mesohaline	0.691	0.110	0.084	.0090	7	0.7	25	6
Lower Mesohaline	0.537	0.050	0.037	.0036	7	1.5	10	3
Corrotoman	0.507	0.027	0.034	.0040	5	1.5	5	3

*summer bottom median concentration

Because of the physical characteristics and loading rates of the Rappahannock basin, the water quality parameters in the estuary that have poor status, particularly water clarity and TSS, and that have degrading trends, particularly TP, are a primary concern. Increased loads of both TSS and TP are closely correlated with the erosive characteristics of the upper basin. And concentrations of both of these constituents are affected by the characteristics of the estuary that maintain high residence times for non-dissolved substances, even in times of high flow. With regard to ecological impacts, water clarity and TSS are believed to be at least partly responsible for degradations in the zooplankton community (fish food) and the subsequent impacts on important fish species, including striped bass. Algal blooms (and subsequent DO problems) in the lower estuary are fed by TP, as well as TN; but TP in particular appears to be the limiting nutrient for algal growth in the Rappahannock for most of the year.

Impaired Waters and Water Quality Standards

There are fourteen segments of river (total of 60.29 miles) in the Rappahannock basin that the state has identified as impaired waters in the 1998 draft 303(d) Total Maximum Daily Load Priority List (TMDL). These include seven segments in the Upper region, three in the Central region and four in the Lower region. Forty-one miles are designated as a result of fecal coliform bacteria violations, ten miles are designated due to multiple causes, and nine miles are designated due to pH violations. The exact sources of these impairments are unknown, however the location of most of them suggests that the pollutants are nonpoint source in origin.

The 1998 draft Water Quality Assessment (305(b)) report identifies these impaired waters by the uses they fail to support, or only partially support. For aquatic life, 16.8 stream or river miles in the basin are designated as impaired. For swimming, 50.9 stream or river miles are designated as impaired. For shell fishing, 11.6 square miles of the estuary are designated as impaired and condemned from shell fishing activity.

The State Water Control Board recognizes that nutrients are contributing to undesirable growth of aquatic plant life (e.g., algae) in surface waters of the Commonwealth and has established a Water Quality Standard of "nutrient enriched waters" (VR680-21-07.3). The board has designated the tidal freshwater and the estuarine portions of the Rappahannock River from the Fall Line to the mouth of the River (Buoy 6), including all tributaries to their headwaters that enter the Rappahannock, as "nutrient enriched waters" based upon an evaluation of the following indicators of nutrient enrichment: chlorophyll *a* concentrations, dissolved oxygen fluctuations, and total phosphorus concentrations. This designation requires the board to modify the NPDES permits of point source dischargers into these waters to reflect effluent limitations on nutrients.

Over objection from the Commonwealth of Virginia, the Environmental Protection Agency has taken action to list portions of the tidal Rappahannock River as impaired, due to dissolved oxygen and living resource impairments. These designations represent a separate manifestation of the problems that are being dealt with through the *Strategy*.

Erosion, Siltation and Bank Instability in the Western Portion of the Basin

A major issue in the western basin are the problems that erosion has caused for farmers, water quality and shoreline property. Although poorly quantified at this time, this problem has been determined to have an impact on the health of streams and rivers in this area. Erosion from the land and shorelines in the upper basin create a snowball effect on downstream erosion, as water currents then act like sandpaper to further erode and dislodge particles as they move downstream. The resulting sediment disrupts benthic communities and smothers the natural rocky substrate that is necessary for survival of a number of species.

Toxics Reduction and Prevention Strategy

The 1987 Chesapeake Bay Agreement committed the signatories to "develop, adopt and begin implementation of a basin wide strategy to achieve a reduction of toxics, consistent with the Clean Water Act of 1987, which will ensure protection of human health and living resources." This strategy was adopted by the Chesapeake Executive Council in January 1989 and initiated a multi-jurisdictional effort to define the nature, extent, and magnitude of toxics problems. The strategy was reevaluated in 1992 and resulted in the Executive Council adopting the *Chesapeake Bay Basin wide Toxics Reduction and Prevention Strategy* in 1994. The goal was established to have the "Bay free of toxics by reducing and eliminating the input of chemical contaminants from all controllable sources to levels that result in no toxic or bioaccumulative impact on living resources that inhabit the Bay or on human health." The revised strategy emphasizes a regional focus for addressing toxic problem areas, additional biological and chemical contaminant assessments in direct support of management actions, complementary activity with existing toxics regulations, and to increase emphasis on pollution prevention.

Regional Focus

The 1994 Toxics Strategy contains a commitment for a toxic contaminant characterization of the tidal tributaries of the Chesapeake Bay, which includes the Rappahannock River. The purpose of the characterization was to establish areas that are not impacted by chemical contaminants, defined as *Areas of Low Probability for Adverse Effects*, to identify those areas that have chemical contaminant problems similar to the existing *Regions of Concern* (e.g., Elizabeth River, areas where serious chemical contaminant problems have been observed) or *Areas of Emphasis* (areas with the potential for serious chemical contaminant-related impacts). A fourth category includes *Areas of Insufficient or Inconclusive Data* where the data are not sufficient to place the area into one of the three categories above. Future management of chemical contaminants will be directed by the outcome of the characterization. For example, ambient toxics monitoring will be targeted in those segments listed as Areas of Insufficient Data. The characterization was finalized in June 1999 (EPA 903-R-99-010).

The area targeted by the toxics characterization in the Rappahannock River includes the tidal areas that range from the mouth to the fall-line. The River was further subdivided into three segments which are described as the Upper Tidal, Middle Tidal, and Lower Tidal segments. The results of the 1999 characterization are as follows:

- *Upper Tidal Rappahannock River* - This portion of the river has been characterized as an Area of Low Probability for Adverse Effects. The characterization is supported by good spatial coverage of recent sediment chemical contaminant data that were at levels that suggested in stream adverse effects would not be occurring to living resources.

- *Middle Tidal Rappahannock River*- The spatial coverage of chemical contaminant data was insufficient to characterize this segment. As a result, this segment was designated an Area of Insufficient Data. To fill in the data gaps and make a definitive characterization, the EPA Chesapeake Bay Program is performing additional monitoring in this segment during late 1999. Chemical contaminant analyses of the water column and sediment will be augmented with ambient toxicity tests plus fish and benthic community assessments.

- *Lower Tidal Rappahannock River* - This segment was characterized as An Area of Low Probability for Adverse Effects. Similar to Upper Tidal portion of the river, there was good spatial coverage of sediment chemical contaminant data that would suggest adverse effects to living resources are not being caused by toxic contaminants.

Directed Toxics Assessment

A Toxics Loading and Release Inventory (TLRI) report was released by the Chesapeake Bay Program during May 1999 (EPA 903-R-99-996). For the Rappahannock River watershed, the TLRI report includes loading estimates from all VPDES dischargers in excess of 0.5 million gallons per day that have been regulated under the Commonwealth's Toxics Management Program. A total of five facilities located above the fall line and three facilities below the fall line were included in the loadings estimates. The report also includes estimations of toxics loadings to the Bay watershed from non-point sources such as urban stormwater runoff, acid mine drainage, pesticide use/runoff, shipping and boating, and atmospheric deposition.

Although the TLRI is not fully comprehensive, and there is some uncertainty associated with each source of contaminant loadings, the results indicate that the Rappahannock River receives relatively low loadings of contaminants when compared to the other basins in the Bay.

Regulatory Program Implementation

The toxics prevention and reduction commitments included in the regulatory section of the strategy build upon existing state and federal statutory mandates. This applies to elimination of toxic impacts from point sources, where significant progress has been attained through the permitting process. Commitments are also included for setting reduction targets for non-point sources which include atmospheric deposition, stormwater runoff and acid mine drainage. Not as much measurable progress has been made with the non-point source discharges, although this topic is an important component of the Toxics Revision and Re-evaluation of the 1994 Strategy.

Another important part of this section was the identification of a list of key chemical contaminants (known as Toxics of Concern) which cause or have the potential to cause problems in the Bay. The original intent of the list was for EPA to develop criteria for the specific contaminants. The jurisdictions then would adopt their own water quality criteria based on EPA's numbers. It has since been determined that EPA will not develop criteria for these listed contaminants. For that reason the utility of the list and the need for future lists has been questioned. Currently, this issue is undergoing discussion in the Chesapeake Bay Program.

Pollution Prevention

The Pollution Prevention Work Group of the Toxics Subcommittee of the Bay Program coordinates and administers the voluntary pollution prevention program "Businesses for the Bay." The focus of the program is to provide public recognition to businesses, government entities, and other organizations who voluntarily reduce their use of hazardous materials and resulting generation of hazardous materials. Businesses for the Bay focuses on reductions of the Bay Program's designated "Toxics of Concern." These reductions are achieved not through additional pre-treatment or conventional control measures, but through proactive pollution prevention techniques such as process changes, increased material usage efficiency, substitution of less toxic materials, improved inventory control techniques, technological upgrades which promote effective material reuse, and improved employee training. Other long-term measures include changes in purchasing policies and "design-for-the-environment" measures, which can account for and minimize environmental impacts from a product in the design stage.

One hundred and fifty Virginia businesses, government entities, and other organizations are participating in Businesses for the Bay. Last year, Virginia members reported a total reduction of 74 million pounds due to pollution prevention measures. In addition, the Virginia members reported pollution prevention training of 4,118 employees and a total cost savings of $900,000 from pollution prevention measures.

Status and Trends for Living Resources in the Tidal Rappahannock River

The major water quality problems in the Rappahannock River continue to be poor water clarity, and low levels of dissolved oxygen in the bottom waters of the lower estuary. Poor water clarity is at least partly responsible for degradations in the zooplankton community (which serve as fish food) and the subsequent impacts on important fish species, including striped bass. Low levels of dissolved oxygen have a tremendous negative impact on the benthic community and also have impacts up the food web on fish and shellfish, including blue crabs.

The majority of the degradations that have been observed in living resource conditions in the Rappahannock estuary can be directly, or indirectly, linked to the water quality parameters discussed in the section above. In a complex system such as the Rappahannock estuary, it may be difficult to determine whether a given aspect of water quality is fully responsible for an observed living resource response. Often, more than one factor will play a role in a causing a degraded living resource condition. Cause and effect relationships are fairly clear for observed impacts on the Rappahannock's benthic community, zooplankton community and fish community. However, what are less clear are the causes for increases in populations of cyanobacteria and bloom-producing algae, and decreases in populations of diatoms and SAV.

Depressed oxygen levels in bottom waters near the mouth of the Rappahannock River have led to severe impacts on the benthic community. This is due to a combination of factors, including elevated nutrient loads reaching the estuary during high flow years, and the higher residence time for nutrients due to poor flushing (caused by a bottom sill at the river mouth). This has led to localized algal blooms and subsequent hypoxia and anoxia during the summer months. Suspended sediment loads are also elevated in the Rappahannock estuary, and this high sediment load is believed to be at least partly responsible for recent declines in the zooplankton community, in certain portions of the river, which has affected the food web. Unwanted bloom producing algae have increased and there was the presence of "Pfiesteria-like complex" reported during the summer of 1997. The fish communities in the Rappahannock have also experienced declines in abundance and diversity, possibly due in part to a decrease in food availability (particularly affecting striped bass). Submerged aquatic grasses in the shallows of the lower Rappahannock estuary have declined significantly in recent years, after reaching a peak in 1990.

Synopsis of Living Resource Status and Trends in the Rappahannock Estuary

- Low dissolved oxygen has negatively affected zooplankton and benthic communities;
- Status of phytoplankton community health was good with the exceptions that there were increasing trends of bloom producers and cyanobacteria in the upper estuary, and decreasing diatom concentrations in the lower region;

- Zooplankton community health showed an improving trend in the middle River but a deteriorating trend in the lower river;
- SAV distribution peaked in 1990 during low rainfall, but declined in recent years; current distributions are well below historical coverage and Bay Program restoration targets;
- Benthic communities were deteriorating in the mid-to upstream Rappahannock River but improving slightly in the Lower Rappahannock River mouth; when comparing baywide, the benthic community was classified as very poor; and
- Least diverse fish community indicating stress.

Phytoplankton Community

Status in phytoplankton community health was good at all stations and no trends in phytoplankton community health were detected. A dominant diatom flora was present throughout the river.   Although the general health status of the phytoplankton is classified as good, there were several mixed patterns in these segments. These include deteriorating (increasing) trends of bloom producing dinoflagellates and cyanobacteria in the upper and middle estuary, and decreasing diatom concentrations in the lower estuary.

There were no significant trends in the algal growth rate and the status for all regions of the Rappahannock River was good. Results of the algal growth limitation experiments indicate the tidal fresh Rappahannock River is light limited throughout the year, but there was some indication of a slight limitation of the algal growth rate due to phosphorus concentrations. The lower portion of the estuary exhibits nitrogen limitation in the summer and fall, and phosphorus limitation in the spring. There was no response to silicate enrichment or light limitation in the lower portion of the estuary.

The lower estuary was the location where members of the dinoflagellate *Pfiesteria* complex were recorded in September 1997. There were no fish kills at this time, but there was a high prevalence of menhaden with lesions in these waters. This event emphasizes the ability of specific toxin-producing species in the phytoplankton community to respond to conditions favorable to their growth. Overall, the phytoplankton composition is favorable, but several negative trends indicate the need to monitor this community closely.

Zooplankton Community

Zooplankton community health showed an improving trend in the middle estuary but a deteriorating trend in the lower estuary. The status for zooplankton community health was good throughout the river. Status of food availability for fish larvae based on zooplankton data was below minimum for all regions. The zooplankton communities of the Rappahannock River showed a mixed pattern of regions of improvement and regions of concern. As in both the York and James rivers the region of concern was the lower region of each tributary which in the case of the Rappahannock is associated with depressed dissolved oxygen levels.

Benthic Community

Benthic communities were deteriorating in the middle Rappahannock estuary but improving slightly in the lower estuary below the region of low to no dissolved oxygen. Status of the benthic communities was considered good at only 25% of the fixed point sampling stations and 38% of the randomly allocated sampling stations. The Rappahannock River contains one of the most degraded benthic community in the Bay with no "marginal" strata for potential improvements. Low dissolved oxygen coupled with heavy total suspended solids loads seemed to be limiting available habitat except in the shallows of this tributary.

Submerged Aquatic Vegetation

<u>Distribution Status and Trends</u>

Historically, SAV, principally eelgrass, were known to be present from the mouth of Rappahannock River up to Morattico. Until recently, there was no historical documentation of SAV above Morattico. Recent flyovers of the tidal fresh portion of the Rappahannock have shown the resurgence of SAV in that area. Currently, the major species in Rappahannock River and its tidal tributaries is widgeongrass, a colonizing species which may fluctuate in distribution and abundance often in the absence of wide variations in water quality. The Rappahannock is the only Virginia tributary showing the presence of SAV in the mesohaline zone (e.g.,1985-1996).

SAV area reached a post-1971 maximum in 1989 in the lower Rappahannock (1,512 acres), and has generally declined since then, with slight increases in 1992-1993 (to 1,021 acres in 1993) and declining again in 1994 and 1995, increasing slightly in 1996 to 267 acres. Most of the SAV in this river is near the Rappahannock and Piankatank river mouths and in the Corrotoman River, although it declined in the Corrotoman in 1995. This area probably supported eelgrass and widgeongrass in the past, since the salinity is usually above 10 ppt. However, it will not support eelgrass under current conditions, based on transplants attempted by VIMS staff.

<u>Habitat Quality Status and Trends</u>

Water quality for SAV growth in lower mesohaline river and Corrotoman had all five requirements met or borderline in all years except in 1990, when the total suspended solids requirement was failed in mesohaline. Thus, there are no obvious causes in these water quality data for the declines in SAV area in the lower Rappahannock in 1994-96. Much of the SAV in this segment is widgeongrass, which tends to fluctuate in abundance over time often in absence of observable variations in water quality.

As noted above, the upper reaches of the Rappahannock have only recently seen the return of SAV beds. In these segments, SAV habitat requirements of light attenuation and total suspended solids were not met in most years. Water quality trends for SAV parameters through 1996 were significant for chlorophyll *a* only, which was improving (going down) in the lower river. The concentrations for dissolved inorganic nitrogen and dissolved inorganic phosphorus were often at their detection limit, making detection of trends difficult. The following table shows current tributary water quality conditions in relation to the five SAV habitat objectives.

Table 2: Rappahannock Estuary - SAV Habitat Objectives

Parameter/Region	Tidal Fresh	Oligohaline	Mesohaline	Polyhaline
Available Light	Fails	Fails	Meets	Meets
Phytoplankton	Meets	Meets	Meets	Meets
Suspended Solids	Fails	Fails	Fails	Meets
Phosphorus	Meets	Meets	Borderline	Meets
Nitrogen	Not applicable	Not applicable	Borderline	Meets

Fish and Shellfish

There are currently some deteriorating signs for fish species in the tidal Rappahannock River. It is possible that these impacts result from two major causes: limited availability of preferred habitat, located between warm surface waters and bottom water, which suffers from low levels of dissolved oxygen; and the decline in preferred food items such as zooplankton communities, the primary food source for a number of commercial and recreational fishes.

In particular, fisheries specialists from Virginia Institute of Marine Science and Virginia Marine Resources Commission have reported declines in menhaden and bay anchovy (not only in the Rappahannock), two smaller species which serve as prey for larger sportfish. As a result, scientists believe that available food for sportfish such as striped bass are very low.

Despite recent increases in striped bass numbers, there is a downside related to stresses in the environment. There is some evidence that striped bass are experiencing overcrowding, relative to the current availability of preferred habitat, the narrow strip of cool, oxygenated water where their preferred food items are found. During the past two years, effects on the striped bass community were observed that may be related to the stress of food availability. Numerous striped bass were found to be in poor physical health, with bacteria-related sores on their body (unlike the lesions caused by *Pfeisteria*) and meager amounts of body fat. Additional studies need to be conducted to verify the causative agents.

Annual catch data for menhaden, alewife, oysters and a number of sportfish in the Rappahannock show dramatic decreases over the past twenty-five years. The reasons for these decreases may include a many factors, other than water quality, such as natural cycles and over harvesting. However, declines in water quality usually create habitat and food stresses that make it more difficult for species to rebound after they have suffered a natural decrease or have experienced severe harvest pressure. Improved water quality conditions allow species and populations to come back more quickly after such events.

IV. Goal Setting for the Rappahannock Strategy

The major objective of the goal-setting process for the *Rappahannock Strategy* was to achieve consensus on basin-wide goals for nutrient and sediment reductions that would restore water quality and living resources in the Rappahannock River and its tributaries. The consensus reached during development of the *Strategy* was support for a robust restoration goal that would substantially remedy water quality problems in the Rappahannock River, its tributaries and the Northern Neck coastal waterways.

It was important to citizens and stakeholders throughout the basin that local water quality issues would be a major focus of goal setting and the *Strategy* effort. Another important objective was the ability to achieve these goals equitably and cost-effectively. Numerous stakeholders and representatives stated that it was important that the final goals were achievable so that efforts would not be destined to fail from the start.

The goal setting process begins with trying to achieve certain water quality objectives for each of the water quality and living resource problems present in the Rappahannock basin. These problems include locally impaired waters, chronic erosion and siltation, diminished submerged aquatic grasses, low levels of dissolved oxygen, and reductions in abundance and diversity of fisheries and other aquatic life. Monitoring information, computer models and other information was then used to establish efficacious, cost-effective and achievable goals.

Rappahannock River Water Quality Objectives

The Chesapeake Bay Program has developed several water quality objectives that help provide standards for Rappahannock River restoration. These water quality objectives represent guideposts for improving, maintaining, and protecting the aquatic ecosystem habitat of the Rappahannock tidal estuary. They depict the current best scientific understanding of the water conditions necessary for a balanced estuarine ecosystem, one that will support healthy aquatic life communities, including the bottom-dwelling benthic community and submerged aquatic vegetation (SAV). Details for the assessment and determination of these water quality objectives are provided in Chesapeake Bay Program (1993), Dennison *et al*. (1993), Batiuk *et al*. (1992), Jordan *et al*. (1992) and Funderburk *et al.* (1991).

The principal water quality parameters of interest are: dissolved oxygen (DO), dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), phytoplankton chlorophyll *a*, light attenuation coefficient (Kd) and total suspended solids (TSS).

Dissolved oxygen is a major factor affecting the survival, distribution, and productivity of living resources in the aquatic environment. Because of the natural fluctuations of DO, and the varied ability of the many key Bay species to tolerate less than desirable DO concentrations, habitat requirements for DO cannot be stated as a single, critical concentration. The sensitivity of each species to low DO depends upon life cycles, temperatures, salinity, duration of exposure, and other stress factors, such as contaminants. By selecting conditions acceptable for the reproduction, growth, and survival of a variety of sensitive species, habitat requirements can be established that will also protect the Bay's other living resources. Dissolve oxygen tolerance information was compiled and interpreted for fourteen target species of fish, molluscs, and crustaceans as reported in Funderburk et al. (1991), including both commercial and recreational fish and shellfish. The DO goals are summarized in Table 3.

Exposure to low dissolved oxygen (DO < 0.5-1.5 mg/l) concentrations have been found lethal, during some life stages, to all of the target species for which exposure information was available. While many species can live in waters with severely depressed (or hypoxic) dissolved oxygen condition (between 1.5 and 3.0 mg/l) deleterious effects were found with growth and reproduction severely compromised.

Table 3 - SUMMARY OF DISSOLVED OXYGEN GOALS*

Dissolved Oxygen Goal	Location & Other Specifications
At least 1.0 mg/l at all times	Throughout the Bay and tidal tributaries, including subpycnocline waters
Between 1.0-3.0 mg/l for less than 12 hours and interval between 1.0-3.0 mg/l longer than 48 hours	Throughout the Bay and tidal tributaries, including subpycnocline waters
Monthly mean of 5.0 mg/l or better at all times	All times throughout waters above the pycnocline
At least 5.0 mg/l at all times	Throughout the water above the pycnocline in spawning reaches, spawning rivers, and nursery areas.

* See Chesapeake Bay Program (1993) and Jordan et al. (1992) for details.

Submerged aquatic vegetation (SAV) refers to underwater vascular plants. This aquatic vegetation performs a number of valuable ecological roles in the Rappahannock River. The plants are major food for waterfowl, and the beds provide habitat and shelter for a variety of fish, shellfish and many smaller organisms which in turn serve as food for the variety of other larger organisms, many of which are valued commercial and recreational fishes. Historically, SAV has generally been abundant in the lower Rappahannock; however, current populations are only a remnant of the once thick beds that provided food and shelter to juvenile fish. The drastic decline of SAV, first noted in the 1970's, sparked the interests of Bay scientists and managers to determine the cause for this significant loss and seek methods to restore this dwindling resource.

It is the general consensus of Bay scientists that the recent loss of SAV in the Rappahannock is due to decreased light penetration throughout the water column and algae growth on the plant surfaces caused by excessive loadings of nutrients and sediments from the watershed. Excessive nutrients and sediments cause increases in turbidity, therefore, limiting light necessary for the plants to grow and reproduce. Habitat requirements most applicable to SAV are those water quality parameters that directly measure or contribute to limiting light conditions, including: dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), total suspended solids (TSS), chlorophyll *a*, Secchi depth, and light attenuation (Kd). While light is the major parameter controlling SAV distribution, nutrients such as nitrogen and phosphorus, indirectly contribute to light attenuation by stimulating growth of algae in the water column and on the leaves and stems of SAV. Chlorophyll *a* is a measure of the amount of algal phytoplankton which contributes to decreased water clarity. Kd is a direct measure of water clarity. Together, these parameters provide for both a qualitative and quantitative measure of the available light to the SAV community (see Table 4).

SAV habitat requirements are defined as the minimal water quality levels necessary for SAV survival. The diversity of their communities coupled with their wide salinity ranges, has led to the establishment of separate requirements based on salinity. Habitat requirements are provided for both one meter and two meter depths for restoration. The SAV habitat requirements provided below were developed by Bay scientists several years ago. A team of scientists is currently reviewing this list of habitat requirements. Their primary goal is to verify their previous studies, refine the requirements as warranted and develop additional diagnostic tools that will help manage this important resource.

Table 4 - SAV HABITAT REQUIREMENTS

One Meter Restoration

Water Quality Parameter	Value	Other Specifications
Light Attenuation (Kd) (m-1)	<2.0 <1.5	For TF[1,2] and OL[1,2] regions For ME[1,2] and PO[1,3]
Total Suspended Solids (mg/l)	<15	For TF[2], OL[2] & ME[2] regions and PO[3]
Chlorophyll *a* (µg/l)	<15	For TF[2], OL[2] & ME[2] regions and PO[3]
Dissolved Inorganic Nitrogen (mg/l)	<0.15	For ME[2] regions and PO[3]
Dissolved Inorganic Phosphorus (mg/l)	<0.02 <0.01	For TF[2] & OL[2] and PO[3] For ME[2] and PO[3]

Two Meter Restoration

Light Attenuation (Kd)	<0.8	For TF[2], OL[2] & ME[2] regions and PO[3]

1 TF=Tidal Fresh (<0.5 ppt salinity), OL=Oligohaline (0.5 to 5.0 ppt salinity), ME=Mesohaline (5.0 to 18.0 ppt salinity) and PO=Polyhaline (>18 ppt salinity)

2 Critical Life Period for SAV is April through October

3 Critical Life Period for SAV is March through November

In order to provide a stepwise measure of progress, the Chesapeake Bay Program established a tiered set of SAV distribution restoration targets. Each target represented expansions in SAV distributions that were anticipated in response to improvements in water quality. **Tier I** describes SAV restoration to areas currently or previously inhabited by SAV as mapped through regional and baywide aerial surveys from 1971 through 1990. **Tier II** is restoration of SAV to all shallow water areas delineated as existing or potential SAV habitat down to the one meter depth contour. **Tier III** is restoration of SAV to all shallow water areas delineated as existing or potential SAV habitat down to the two meter depth contour.

Goal Setting Using the Chesapeake Bay Computer Water Quality Model

Results from the Chesapeake Bay computer water quality model indicate that further reductions in nutrient and sediment loads in the Rappahannock basin will significantly improve water quality and living resources in the Rappahannock River. Using this computer model, a series of possible nutrient and sediment reduction goals have been evaluated for their effect on water quality, particularly their effect on levels of dissolved oxygen, SAV habitat conditions and other water quality objectives discussed above.

One such goal, which would lead to considerable water quality and living resource improvements, originated from a Chesapeake Bay computer model run termed "Full Voluntary Participation" (FVP). Implementation of FVP levels of nutrient and sediment reductions throughout the Chesapeake Bay would reduce the annual amount of anoxic waters - "dead" waters that have no oxygen - in Rappahannock River by a projected 80% (anoxia would be eliminated in most rainfall years). However, if FVP levels of reductions were only achieved in the Rappahannock basin (maintaining loads from upper Bay river basins at "tributary strategy levels"), the annual amount of anoxic waters in Rappahannock River would be reduced by 57%.

Determinations on Goals by River Basin Commission and Technical Committee

The level of water quality restoration that is represented in the Baywide FVP model run was unanimously supported by the local and state officials who serve on the Rappahannock River Basin Commission (Commission), at their meeting on December 16, 1998, and by the diverse group of stakeholders who serve on the Rappahannock Technical Committee (RTC), at their January 8, 1999 meeting.

The Commission's support of the FVP levels of nutrient and sediment reductions and water quality restoration for the Rappahannock River, was conditioned upon three stipulations:

- The *Rappahannock Tributary Strategy* remains voluntary;
- Sufficient cost-share funds will be available to support implementation; and
- The mix of practices used to reduce nutrients and sediments will be determined locally.

In addition to the Commission, many local governments adopted resolutions in support of the FVP level of water quality restoration for the Rappahannock River. These resolutions reflect the above stipulations of voluntary program, sufficient cost-share funds and local determination.

Local determination of nutrient and sediment controls is already a key element of Virginia's Tributary Strategy Program. This determination is made through an "assessment process," conducted in cooperation with local point source and nonpoint source stakeholders in each tributary basin. During the assessment, point source and nonpoint source representatives throughout the Rappahannock basin cooperatively identified possible implementation practices and scenarios that could help achieve nutrient and sediment reductions in the Rappahannock basin. The assessment process for the Rappahannock basin was conducted in the fall of 1998.

Using the results of the assessment, the RTC determined that it would be very difficult or impossible to achieve FVP levels of sediment and nutrient reductions (particularly nitrogen) from point sources and nonpoint sources in the basin by a reasonable deadline (e.g., 2010). Even the most aggressive implementation scenarios failed to achieve FVP nitrogen reductions prior to 2014. The RTC members did not want to establish a deadline that would promote delays in implementation; nor did they want to establish a goal that would set up people in the basin for failure. Furthermore, participants expressed concern that the annual rates of agricultural BMP implementation identified in the assessment may decrease before 2015 (and possibly before 2010), further extending the time needed to meet the FVP goal. Finally, achieving the full FVP level of water quality restoration requires that river basins to the north achieve nutrient reductions greater than their respective tributary strategy levels (because these loads affect the Rappahannock River); and it is not currently known whether this is attainable.

Therefore, the level of water quality restoration represented by FVP is maintained in the *Rappahannock Strategy* as a **Vision for Rappahannock River Restoration**. But the specific nutrient and sediment reductions associated with this Vision have not been committed to and are not tied to a deadline.

The members of the RTC voted unanimously to support a nutrient and sediment reduction goal that would still greatly improve Rappahannock River water quality and would be attainable by 2010. One of the Chesapeake Bay computer model runs, termed "BNR-BNR Equivalent" represented an aggressive nutrient and sediment reduction goal that would lead to significant water quality improvements (see Table 5). In addition, this model run reflected levels of nutrient and sediment reductions which are within a reasonable range of those developed through the high-end reduction scenario of the assessment process (phosphorus and sediment reduction goals may be achieved before 2010; the nitrogen goal is more of a challenge). The TRC voted to support this goal and to include program evaluations and technical evaluations in the *Rappahannock Strategy* to assess ways in which to close any remaining nitrogen gaps and achieve the FVP Vision for Rappahannock River Restoration as quickly as possible.

The two restoration goals for year 2010 associated with BNR-BNR Equivalent level of reductions in the Rappahannock River and Northern Neck coastal basins are:

- to reduce by approximately 50% (actual model prediction is 45%) the annual volume of anoxic water (water that has no dissolved oxygen) in Rappahannock River, and
- to increase by approximately 50% (52% prediction) the density of submerged grasses.

The necessary nutrient and sediment reductions associated with the BNR-BNR Equivalent model run are:

- Nitrogen - 33% reduction (target nitrogen load of 6,949,000 lbs/year)
- Phosphorus - 29% reduction (target phosphorus load of 663,000 lbs/year)
- Sediment - 20% reduction (target sediment load of 289,000 tons/year).

These goals were set forth in two drafts of the *Strategy* (February and July of 1999).

(Note: there is a difference between how nutrient load reductions were calculated for the Shenandoah and Potomac Tributary Strategy, and how they are being calculated for Virginia's lower Chesapeake Bay tributaries. Nutrient reduction percentages for the Shenandoah/Potomac Strategy were based on controllable loads; while nutrient reduction percentages for lower Bay strategies are based on total loads. Therefore, for example, the 33% BNR-BNR Equivalent reduction level in total nitrogen represents a 38% reduction in controllable nitrogen load.)

The Challenge of the Nitrogen Reduction Goal

At the time of the February 23, 1999 draft of the *Strategy*, information was not yet available on point source nutrient load increases (to the goal year of 2010) that would result from population growth in the Rappahannock River and Northern Neck coastal basins. The Commission was informed of this fact during a presentation at their March, 1999 meeting, and the Commission directed that these figures be developed and placed in the *Strategy* in order to accurately reflect projected point source flow increases in the basin to the year 2010.

Due to the rapid growth in population anticipated in the Rappahannock basin (particularly the central region) over the next decade, this revision brought the sum of *Strategy* implementation practices even farther away from meeting the nitrogen goal. Under current estimates, the sum of point and nonpoint source implementation practices achieves a level of nitrogen reductions that is 9 percentage points short of the 33% reduction goal.

The RTC decided that the issue of this substantial nitrogen gap needed to be brought before the Commission prior to the development of a final *Strategy*. This was done at their May meeting. At that meeting, the Commission was presented with three options: reduce the nitrogen reduction goal in the Strategy; delay the final Strategy until further nitrogen reduction practices are identified to close the nitrogen gap; and maintain the current nitrogen goal and set forth continued planning efforts to identify nitrogen reduction practices. The Commission elected the third option, to maintain the current nitrogen goal, recognizing that *Strategy* implementation actions currently fall short of this goal, and that further planning would be needed to identify additional implementation actions and management practices.

Additional Tributary Strategy Goals

The Chesapeake Bay computer water quality model in its current form does not have the capability to simulate the degree of water quality improvements that will be achieved in the western portion of the Rappahannock basin as a result of management practices implemented under the *Strategy*. However, there is clear evidence and data that the streams and rivers in this area has suffered degradations in water quality and living resources, and that the *Strategy* management practices would lead to water quality improvements.

Throughout the *Strategy* process, citizens, representatives and local officials from the western basin described these water quality problems and stated that restoration of local water quality in the western basin needed to be preeminent within the final *Strategy*. As a result of these concerns, *Strategy* goals were developed that would improve water quality, in addition to the improvements that would result from achieving the nutrient and sediment reduction goals.

To address chronic erosion and stream bank instability in the western Rappahannock basin, an additional goal of the *Strategy* is to promote Governor Gilmore's proposed Conservation Reserve Enhancement Program (CREP) and to:

- Implement CREP in the Rappahannock basin by reestablishing 4,604 acres of riparian buffers (equal to 491 stream miles at a width of 75 feet) and 456 acres of wetlands.

The *Rappahannock Strategy* also identifies the following goal, which is mostly applicable to the western portion of the Rappahannock basin:

- Remove all stream segments from the 303(d) Impaired Waters list which are impaired as a result of localized pollutant loads in the basin.

The nutrient and sediment reductions that will be achieved through implementation of the CREP program are included in the *Strategy* calculations for nonpoint source reductions to year 2010. The goal of removing stream segments from the Impaired Waters list will likely be assisted by many of the nonpoint source practices already included in the *Strategy*; however, additional monitoring, planning and implementation will likely have to be accomplished in addition to what is currently included in the *Rappahannock Strategy*.

V. Anticipated Water Quality Benefits of the Strategy

Basin wide Water Quality Benefits

A clear consensus was reached during the development of the *Rappahannock Strategy* that the goal of the *Strategy* is to improve water quality conditions throughout the Rappahannock basin. Water quality issues and problems vary across the basin, and among the diverse tributary rivers and streams. Current scientific knowledge of water quality and living resources in the Rappahannock River is heavily weighted toward the tidal regions of the River, mostly because of the studies and funding that originated in the Chesapeake Bay Program. Substantial water quality information has been collected in the western portion of this basin

The anticipated benefits of achieving the BNR-BNR Equivalent level of nutrient and sediment reductions in the Rappahannock River and Northern Neck coastal basins relate closely to the reestablishment of a healthier aquatic habitat. The best quantification of these benefits has been accomplished through the Chesapeake Bay computer water quality model for the tidal Rappahannock. The most noticeable aquatic habitat improvements from reduction programs would be improvements to dissolved oxygen and bay sea grasses in the tidal areas, and improvements to benthic communities throughout the Rappahannock River and Northern Neck coastal basins.

Dissolved Oxygen Improvements

Actual reduced volume of anoxia per season in the Rappahannock River will vary from year to year. However, on average, anoxic conditions will improve by approximately 45%. This improvement will not only affect the water column, but will also lead to rehabitation of river bottom areas by benthic invertebrates, which are critical components of the aquatic food web (Refer to Table 5 for a comparison of loading reductions and anticipated water and habitat quality improvements).

The Chesapeake Bay computer water quality model results also indicate that a large volume of water (22% improvement) in the Rappahannock River that currently becomes hypoxic (very low levels of dissolved oxygen) during the summer and early fall will now meet deep water habitat conditions for dissolved oxygen. This will reduce stresses on fish that travel through these zones. In particular, it will allow a number of species including striped bass to expand their habitats to cooler, deeper waters during the critical summer months.

Figure 3 illustrates the improvements in dissolved oxygen that will be anticipated in the tidal Rappahannock River as a result of achieving BNR-BNR Equivalent levels of nutrient and sediment reductions, comparison to 1996 conditions, Full Voluntary levels of nutrient and sediment reductions within the Rappahannock basin, and Full Voluntary levels of reductions throughout the Chesapeake Bay Watershed.

Impaired Waters Improvements

Having all streams, rivers and bays in the Rappahannock River and Northern Neck coastal basins meet state and federal water quality standards is an important goal that will lead to numerous benefits. The water quality benefits that will be achieved from this action are clear. However, what may be most important from meeting this goal are the benefits of public concern and perception that are difficult to quantify. When citizens and local officials see that the actions they have taken to clean up their streams and rivers have led to these waters being fully "fishable and swimmable," it ensures that they will continue to value these efforts. It will demonstrate that these kinds of actions bear direct fruit and that individuals can have a very important impact on water quality.

Living Resource Benefits

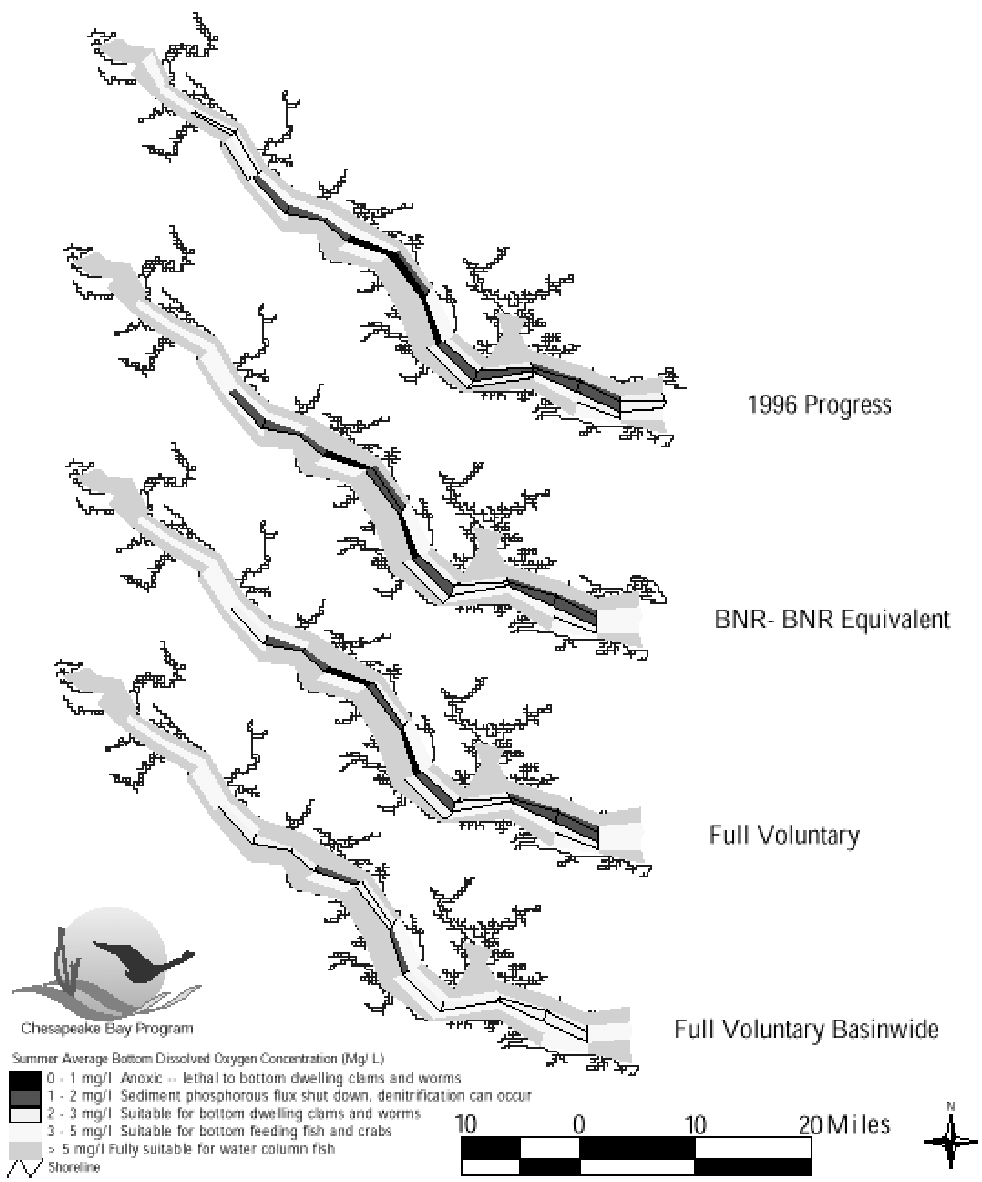
Living resource benefits in Rappahannock River will occur when the habitats, food sources and ecological relationships have been restored. Habitats are the places where plants and animals live, feed, find shelter, and reproduce. Habitats may be relatively small, such as a community living on and around an oyster reef, or may encompass an entire estuary such as the Rappahannock River. If the system becomes stressed due to various manmade or large natural changes, the habitat may become unsuitable for one or more organisms to live resulting in a local or regional decline in the populations.

Since the low dissolved oxygen conditions in the lower Rappahannock seem to be caused by watershed nutrient loadings and within river blooms of algae, further reducing nutrient loads within the basin should control phytoplankton growth and, thereby, reduce their over production. This, in turn, would decrease oxygen depletion through the reduced production of phytoplankton not preyed upon by zooplankton and plankton eating fish that would otherwise sink to the bottom sediment and undergo the natural process of organic decay. In order to best control phytoplankton production, reducing both phosphorus nitrogen loadings was recommended given both have a role in limiting phytoplankton growth in the Rappahannock.

Zooplankton Improvements

Another community that would benefit from improved oxygen conditions are zooplankton. There was evidence that zooplankton communities that live in the water column in the lower section of the river were adversely impacted by low dissolved oxygen concentrations. Therefore, measures to improve the dissolved oxygen conditions should improve zooplankton communities. Such action would not only improve available fish food, but should help prevent phytoplankton blooms by grazing down phytoplankton communities.

Improving Summer Bottom Dissolved Oyxygen In the Lower Rappahannock River



Benthic Community Improvements

The Rappahannock River displays one of the most degraded benthic communities in Virginia waters. Low dissolved oxygen waters in the tidal Rappahannock represent 77% of the total anoxic waters in Virginia. As bad as this condition is for the health of the aquatic food web, it is recoverable through elimination of no oxygen/very low oxygen conditions. Increased levels of dissolved oxygen in the lower Rappahannock River would have tremendous effects on the recovery of the benthic system, which would serve as a much improved habitat and food source for fish, and for other important components of the food web of the Rappahannock River and Northern Neck coastal waters (and also to species that migrate among the Rappahannock River, the Chesapeake Bay and even the Atlantic Ocean).

SAV and Near Shore Habitat Improvements

While deeper habitats are impacted by low dissolved oxygen, the shallow waters along shoreline fringes also serve as critical nursery grounds and refuge for many aquatic organisms. One such community is submerged aquatic vegetation (SAV). Sea grass beds perform a number of valuable ecological roles in waters of the Bay. To support full restoration of sea grass to the lower Rappahannock River a period of sustained high water quality and local sources of propagules is required. Based on analyses of the types of pollutants that limit light reaching SAV in Rappahannock River, reductions in total suspended solids are needed to support reestablishment of SAV in the upper river, while reductions in total suspended solids, nitrogen, and phosphorus are needed in the lower Rappahannock.

Improved water clarity would provide the necessary habitat conditions for expansion of sea grass beds in the lower river and re-colonization of other sea grasses in the fringing tributaries. Model simulations indicate that both area and density of submerged aquatic bay grasses will improve under Strategy implementation for the Rappahannock Basin. In particular, as the density of bay grasses reach a critical level, the entire bed becomes healthy enough to withstand temporary periods of poor water quality. In addition, these beds begin to filter and settle sediments in the water column, thereby further promoting conditions suitable for further growth and reestablishment.

Conservation Reserve Enhancement Program Benefits

Restoring smaller streams, river systems and riparian areas in the western portion of the Rappahannock basin will improve the habitat conditions of these riverine systems that support a variety of freshwater sport fish. Riparian areas, buffers and wetlands naturally store floodwater and settle out high loads of sediments which typically accompany storm events. Stabilizing the natural hydrology of streams and smaller rivers will help stabilize and hopefully reverse the chronic bank erosion being experienced in these tributaries. In addition, restored riparian wooded areas have many other beneficial effects on water quality, including shading and cooling to the host of aquatic freshwater organism. Removing all stream segments in the basin from the impaired waters list will lead to a variety of environmental improvements that have substantial benefits for recreation, tourism and many other uses of these waterways.

Economic Benefits

The many benefits anticipated from improvements in water quality will serve the industries that depend on clean water and healthy rivers. In addition, many of the top companies in the country consider quality of life and environmental factors in their decisions on where to locate business facilities. A clean and healthy Rappahannock River will offer this incentive to companies that consider environmental issues in their business decisions.

Water quality and living resource improvements should cause positive shifts in populations of aquatic plants and animals. Such benefits to the basic food web will help foster healthier fishery populations throughout the Rappahannock River. This level of restoration of fishery stocks will provide great benefits for watermen, sport fishermen and others throughout the Rappahannock River and Northern Neck coastal basins.

VI. Implementation Actions, Management Practices and Estimated Load Reductions

Building on a Strong Foundation of Conservation and Stewardship

A basic tenet of the *Strategy* is to build upon the conservation ethic that is very strong across the Rappahannock River and Northern Neck coastal basins. Farmers, local officials, soil and water conservation district staff, extension agents, wastewater treatment plant operators and conservation groups in this region have undertaken many actions and programs to improve water quality in recent years. These efforts provide an excellent foundation for implementation of additional practices and programs that will lead to the restoration of the Rappahannock River.

Cooperative Process for Identifying Management Practices

The management practices that will be implemented over the next decade to meet *Strategy* goals were selected by stakeholders through a cooperative process. This process included representatives of point sources and nonpoint sources in the basin and was conducted under the auspices of the RTC. In selecting appropriate practices, the representatives were guided by the major principles of Virginia's Tributary Strategy Program: local determination; cost-effectiveness; equity among types of sources; availability of cost-share funding; and voluntary implementation.

Point Sources - Actions and Load Reductions

Biological Nutrient Removal

Biological nutrient removal (BNR) is accepted as the most effective technology available for nutrient reduction at municipal wastewater treatment plants. BNR can be operated to remove both nitrogen and phosphorus concurrently or optimized for nitrogen removal and paired with chemical phosphorus removal. In some plants that install BNR, nitrogen concentration in discharge can be reduced to 8 mg/liter, or even less to 6 or 7 mg/liter.

Numerous reference papers, written by experts on BNR technology, have supported the beneficial aspects of BNR. They state that BNR can result in process and operating benefits, notably reduced energy and alkalinity consumption due to denitrification aspects of these processes, and improved process stability due to reduced likelihood of sludge bulking. In some cases, the energy savings from reduced oxygen requirements more than offset the power usage for mixing and recycle pumping. If properly designed and operated, BNR typically improves sludge settleability and control of filamentous microorganisms. In full-scale BNR demonstrations, increased nitrification rates in the aerated zone have been seen.

Assessment Process for Rappahannock Basin Point Sources

Point source nutrient loads in the Rappahannock River and Northern Neck coastal basins represent less than 10% of the total delivered nitrogen loads, and around 10% of total delivered phosphorus loads (point sources do not contribute to sediment loads). Despite this small percentage of load, point source facility owners in the basin have demonstrated strong commitment to being partners in the Rappahannock restoration effort.

A point source workgroup was established to identify point source nutrient reduction opportunities in the Rappahannock basin. Membership on this workgroup was initially based on expressed interest. Membership was expanded as decisions of the workgroup potentially affected other wastewater treatment plants. Workgroup members coordinated their efforts and decisions with the Virginia Association of Municipal Wastewater Agencies.

Past and Planned Implementation Actions

Four of the major municipal wastewater treatment plants in the basin - Remington, FMC, Fredericksburg and Little Falls Run - have already implemented nutrient removal technology voluntarily. As part of the *Strategy* process, the remaining facilities with permitted flows greater than one million gallons per day (except Warrenton) in the basin have included BNR in their planning process and have taken steps toward implementation. These plants, including Culpeper and Massaponax, have not finalized their plans and schedules for implementing BNR. However, it is anticipated that these upgrades will be completed prior to the *Strategy* deadline of 2010; and it is likely they will be completed long before then.

These past and planned efforts by point sources (and their respective county boards and service authorities) to achieve total nitrogen concentrations of 8 mg/l are important contributions to the nutrient reduction goal of the *Strategy*. Both past and planned nutrient removal initiatives undertaken in the Rappahannock basin are represented in the *Strategy* as eligible for cost-share reimbursements under Virginia's Water Quality Improvement Fund (VWQIF).

An independent study of the Warrenton wastewater treatment facility was conducted to assess suitability for BNR. The study indicated that the facility is poorly suited to application of BNR; and installation of BNR at Warrenton is not included as a component of the *Strategy*. However, the Department of Environmental Quality will continue to work with the owners of this facility to take advantage of any opportunities that may arise. Should this facility undertake a BNR upgrade, the resulting nutrient reductions would be a valuable contribution to the *Strategy*; and this initiative would be eligible for cost-share funding under the VWQIF.

Anticipated Load Increases

Implementation of BNR (8mg/l nitrogen and 1.5 mg/l phosphorus) at all treatment plants of permitted flows greater than 1 MGD (excluding Warrenton) would yield a 10% reduction in nitrogen levels and a 59% reduction in phosphorus levels, relative to the 1985 baseline year, if flows were maintained at current (year 2000) levels. However, as a result of the high level of population growth that is expected in the Rappahannock basin over the coming decade, these flows are expected to dramatically increase through to the goal year of 2010; and most of those gains in nitrogen reduction will be overtaken by increased levels of wastewater flow. Table 6 shows the increased levels of nitrogen loadings that are anticipated at year 2010, even with the planned implementation of BNR at plants with flow rates greater than 1 MGD.

Agricultural Nonpoint Sources - Actions and Load Reductions

Nonpoint source nutrient loads in the Rappahannock River basin represent over 90% of total delivered nitrogen loads and approximately 90% of total delivered phosphorus loads (and 100% of total delivered sediment loads). Agricultural nonpoint source loads represent the vast majority of these loads; and achieving the reduction goals of the *Strategy* will depend mostly on the success of increased and sustained rates of agricultural BMP implementation in the basin. However, reducing the urban (including suburban) components of the nonpoint source nutrient and sediment loads will also be very important in the coming years.

General Principles Guiding Funding and Implementation of Agricultural Practices

The following principles for guiding development and funding of conservation projects under the *Strategy* were offered by conservation officials in the basin.

- Voluntary - Implementation of the *Strategy* should remain voluntary.
- Cost-effectiveness - Projects should be prioritized which have the greatest chance of achieving unit reductions at the lowest available cost.
- Adequately trained staff - Effective implementation will require sufficient levels of staff who are adequately trained to provide needed technical assistance.
- Agricultural enhancement - Projects should be prioritized which reduce loads and which also serve to promote the viability of agriculture in the basin.
- Multiple pollutants - Projects should be prioritized which address the reduction of more than one pollutant of concern (e.g., fecal coliform, sediments, nitrogen).
- Cooperative projects - Projects should be prioritized which are cooperative projects among soil and water conservation districts and local governments; more than one local government; or public and private sector.
- Targeting - Projects should be prioritized which target areas of high nutrient, sediment and/or fecal coliform loads to enhance cost-effectiveness, education and demonstration.
- Ancillary benefits - Projects should be prioritized which provide additional benefits to the Rappahannock basin (such as the wildlife habitat provided by riparian forest buffers).
- Innovative projects - Projects should be prioritized which offer innovative solutions to achieving reductions. In particular, projects should be undertaken and funded which achieve reductions even under high rainfall events and seasons.

Assessment Process for Agricultural Nonpoint Sources

In the fall of 1998, a meeting was held that brought together extension agents, SWCD representatives, NRCS staff and Department of Conservation and Recreation staff to discuss the *Rappahannock Tributary Strategy* and the assessment of agricultural BMP implementation in the Rappahannock basin. This group determined that the diversity of agriculture land uses present in the basin warranted separate, regional meetings to define potential rates of BMP implementation.

Staff of the Department of Conservation and Recreation directed four regional meetings of agricultural conservation staff. These conservation staff were asked to estimate the levels of BMP implementation, for each type of practice, that could achieved in each locality of the basin under the two possible scenarios. These were defined as:

- **Low end scenario** - All cost-share programs are fully funded; and
- **High end scenario** - In addition to full funding, implement program changes and enhancements for improving the cost-share program (including increased staff levels)

The local agricultural conservation staff projected annual rates of BMP implementation for each type of conservation practice, under these two scenarios, and put forth their best ideas on the kinds of program enhancements (these are listed in the following section) that could help achieve the high end implementation scenario. These annual BMP implementation rates were aggregated for the entire Rappahannock basin and were calculated out to the year 2005, which was an initial consideration as a deadline for the *Rappahannock Strategy*. These calculations indicated that phosphorus and sediment reduction goals would be reached by 2005 (including point source reductions); but even under the high end scenario, nonpoint source and point source reduction levels in the basin would fall far short of the 33% nitrogen goal by that year.

As a result of these calculations, annual nonpoint source BMP implementation rates were extended to 2010 to evaluate sufficiency in meeting nutrient and sediment goals. In addition, the reductions associated with full implementation of Virginia's proposed Conservation Reserve Enhancement Program were included with the Strategy calculations (see Table 7). Under those circumstances, total point source and nonpoint source reductions of phosphorus and sediment loads will surpass *Strategy* goals. However, total nonpoint source and point source nitrogen reductions will be approximately 9% short of achieving the *Strategy* goal at year 2010.

Implementation Actions and Issues

Farmers in the Rappahannock basin have demonstrated that they are stewards of the land and are willing to do their part to protect water quality. However, it must be recognized that there are challenges that must be met in order to increase implementation of agricultural BMPs.

Achieving full implementation of the agricultural management practices identified in Table 7 represents a significant commitment and undertaking by farmers and agricultural staff in the

Rappahannock basin. Many of the program enhancements and developments that will be needed to bring the sum of these practices to full fruition are described in the following two chapters. However, it should be recognized that even reaching the level of implementation that is identified in the current *Strategy* may require substantial changes and improvements in areas of education and marketing; landowner eligibility; technical assistance (from paperwork to facility installation); maintenance; and tracking.

In addition, it is important to recognize that the agricultural economy in Virginia has been beset by numerous challenges, including competition, land taxes, climate and a host of others. The economic status of farmers plays a strong role in their ability to undertake conservation actions during any given year; and these factors must be taken into consideration during the implementation of the *Strategy*.

Staff of the Virginia Department of Conservation and Recreation, Virginia Cooperative Extension Service and Virginia Department of Agriculture and Consumer Services have been working closely with farmers, and the *Strategy* initiative, for a number of years; and these effective relationships will need to continue. Farmers in the Rappahannock basin have demonstrated a strong stewardship ethic, and this ethic will need to be fostered in order to restore water quality in Rappahannock River.

Total Anticipated Load Reductions Under Full Strategy Implementation

All current information indicates that the sum of point and nonpoint source practices identified in the *Strategy* will be sufficient to meet the phosphorus and sediment reduction goals by the goal year of 2010. However, these practices, when combined with expected increases in nitrogen loads from population growth in the Rappahannock basin, will not be sufficient to meet the nitrogen reduction goal.

Under current projections, progress toward the nitrogen reduction goal will represent a 24% reduction from the 1985 baseline nitrogen load, 9% points short of the 33% nitrogen reduction goal represented in the BNR-BNR Equivalent Chesapeake Bay water quality model run for the Rappahannock River and Northern Neck coastal basins.

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Implementation Costs

Costs for nutrient and sediment reduction practices will be paid for using a combination of state, local and individual funds. The state cost-share portions of these actions taken over the next eleven years (1998 dollars) is estimated to be $8,791,000 for point sources (assuming 50% cost-share), and $39,366,000 for nonpoint sources (assuming 75% cost-share, including any needed staff and technical resources). These figures are planning level estimates.

Point Source Costs

The BNR-related costs that have already been incurred in the Rappahannock basin include: Fredericksburg - $4,798,050; Little Falls Run - $2,076,000; Remington -$922,000; and FMC - c.a. $300,000. The total projected costs (planning level estimates at 1998 dollars) of further BNR upgrades are: Culpeper - $4,193,000; and Massaponax - $5,262,000. Total Estimated Cost = $17,582,000

It is expected that the four treatment facilities in the basin that have already installed nutrient removal sytsems will make reimbursement requests immediately for $4,048,000 state cost share. One major facility is expected to upgrade to nutrient removal technology in the next one or two years, with a state cost-share request of $2,631,000.

Agricultural Nonpoint Source Costs

The total estimated cost-share amount needed for eleven years of agricultural BMP implementation is approximately $31,493,000 for BMPs and $7,873,000 for technical resources. Total Estimated State Costs = $39,366,000. The estimated annual average state cost for implementing the identified nonpoint source management practices is $3,579,000. This figure may increase beyond 2005, as it becomes necessary to implement more costly (per pound of nutrient or sediment removed) management practices in order to maintain, or increase, the annual rates of nitrogen reduction.

The costs for implementing Virginia's Conservation Reserve Enhancement Program in the basin are not included in the *Strategy*, because they are part of a separate budgetary initiative. Also not included are any costs that may result from implementing practices necessary to address Impaired Waters in the basin. These will be included in future updates to the *Strategy*.

Urban and Suburban Nonpoint Source Costs

The types and numbers of urban and suburban nonpoint source practices that will be put in place for *Strategy* implementation have not yet been determined. However, these practices will be important components of meeting *Strategy* goals; and some portion of cost-share funds should be made available for these practices even before final cost projections are made. As these costs are developed, they will be included in future updates to the *Strategy*.

VII. Recommendations and Program Enhancements

Closing the Nitrogen Gap

The Rappahannock Technical Committee and other stakeholders recognized that there are certain elements of the *Rappahannock Strategy* that need continued consideration and refinement in order to make the *Strategy* as effective as possible. In particular, additional nutrient and sediment opportunities need to be considered which can help to close the gap between our projected nitrogen reductions to 2010 (determined through the assessment process) and the BNR-BNR Equivalent reduction goal. The TRC voted to continue their efforts and to also establish one or more working groups that would address these elements.

Closing the 9% nitrogen gap is particularly important for improving dissolved oxygen conditions in the lower Rappahannock River because nitrogen is the nutrient that controls algae growth during the summer months. To fully achieve the anticipated water quality and living resource benefits of the Strategy, sufficient management practices will have to be identified that are capable of closing the nitrogen gap.

Any identified enhancements to the *Strategy* will be documented through the Secretary of Natural Resource's Annual Report to the General Assembly on the Development and Implementation of Nutrient Reduction Strategies for Virginia's Tributaries to the Chesapeake Bay (produced in November of each year).

Point Source Recommendations

Even if additional reductions are achieved in the total point source nitrogen load, these reductions will not be able to account for the nitrogen gap because point source loads are a relatively small component of total nitrogen loads in the basin. However, these options may play an important role in closing that gap where increased nutrient treatment capabilities are incorporated into wastewater treatment plants in the Rappahannock basin through incentive programs or other means.

Research and Testing of New Point Source Nutrient Removal Technologies

The principal, cost-effective technology that is currently available for nutrient removal is biological nutrient removal. Participants in the *Strategy* process recognize the value of this technology; however, they also recognize that new technologies are becoming available in many areas of pollution prevention and reduction. As these technologies become available, they should be quickly tested for their effectiveness, cost and suitability, particularly with respect to potential nitrogen reductions.

Continued Support for BNR Feasibility Studies

One of the most important steps in the implementation of nutrient removal technology at wastewater treatment plants has been the sponsorship of facility reviews by experts in the field. Funded by the state and federal governments, these reviews provide facility operators with an understanding of the suitability of their facility to the installation of nutrient removal technology and the operational changes it may require.

State agency staff will continue their efforts with small and mid-size treatment plants in the basin to promote and fund suitability studies for installation of nutrient removal. Two additional plants in the Rappahannock basin are currently scheduled for this type of study in the fall of 1999.

Incentive Option

The wastewater treatment plants in the Rappahannock basin, particularly in the central region, face a very high growth rate during the implementation period of the *Rappahannock Strategy*. It is difficult to accurately predict the increased wastewater flow levels that will result from this growth by the year 2010; however, they are likely to be considerable.

This high growth rate is juxtaposed against the water quality problems that are occurring in the Rappahannock River and the challenging restoration goal that has been established by participants in the *Strategy* process. Because of these circumstances, an important consideration by the Department of Environmental Quality is the option to provide incentive grants for upgrades of wastewater treatment plants in the Rappahannock basin that would lead to discharged concentrations of total nitrogen that are below 8 mg/l (e.g., 5-6 mg/l). Under this approach, actions taken beyond a standard BNR upgrade could be eligible for cost-share funding up to 75%. An additional consideration is the option to provide an increased cost-share funding percentage for implementation of nutrient removal technology at the Warrenton facility, due to problematic circumstances inherent in the design of this wastewater treatment plant.

Nutrient Trading

Unlike most other pollutants, the adverse water quality impacts of nutrient overenrichment are generally associated with total loadings throughout an entire watershed. Consequently, two or more nutrient sources may be able to take advantage of trading to achieve more cost-effective reductions without localized water quality impacts. Trading can also serve to achieve additional water quality benefits. For example, trading ratios can be employed in appropriate cases to promote reductions greater than would be otherwise achieved.

In its simplest terms, trading involves reductions greater than needed or required by one source to create “credits,” which are then used by another source in place of achieving those needed reductions directly through facility upgrades or BMP installation. The source receiving the credits is generally expected to compensate the source providing the credits. An incentive to trade exists when the source of credits receives more for the credits than the cost of creating them, and the source receiving the credits pays less for them than the alternative cost of achieving those reductions on their own.

Initiatives are underway to develop guidelines that would govern nutrient trading under tributary strategies. While it is unlikely that any complex form of nutrient trades can be performed until these guidelines are in place, simple trades such as those between a large wastewater treatment facility and a smaller facility are possible, and are encouraged. Small or mid-sized treatment facilities constrained by financial, technological or logistical considerations may find it beneficial to achieve their nutrient reduction goals by buying credits on an annual basis from larger facilities whose equivalent or greater reductions can be achieved at far less cost.

Agricultural Nonpoint Source Recommendations

Issues Important to Agricultural BMP Implementation

Conservation officials in the basin identified four areas of concern which will be key to the long-term success or failure of the Rappahannock Tributary Strategy. Addressing these will be an important component of increased and sustained BMP implementation. They are:

- The high degree of farmland rental in the Rappahannock basin (particularly the eastern portion) discourages installation of structural BMPs or improvements;
- Certain types of land uses, which are not farmland but which cover a lot of acreage in the basin, are not eligible for BMP cost-share funds.
- Current agricultural BMPs are not well designed to reduce nutrient and sediment loads in the face of larger rainfall events, such as those that have recently occurred in the basin.
- BMP implementation rates are partly dependent upon the farm economy for a given year.

It is not currently known how these concerns will be specifically addressed in order to maintain or increase rates of BMP installation. As the *Strategy* enters the implementation phase, ideas and possible solutions for these concerns will be identified.

General Needs and Recommendations

Agricultural conservation officials in the Rappahannock basin support an agricultural BMP program that builds upon the successful conservation efforts that have already taken place. However, these officials also generally agree that increased and sustained rates of BMP implementation to meet the reduction goals of the *Strategy* will require programmatic improvements and changes in a number of areas, including:

- Better utilization of existing staff; additional staffing, if required;
- Increased eligibility of certain practices and types of land uses;
- Better education, marketing and information;

- Improved technical resources;
- Improved coordination and leveraging among funding sources and programs (including proposed Conservation Reserve Enhancement Program);
- Enhanced geographic targeting (to address local water quality problems);
- Enhanced targeting/promotion of high priority practices;
- Increased involvement by the private sector for farm plans and nutrient management planning; and
- Streamlined paperwork.

Specific Agricultural BMP Cost-Share Program Recommendations

The following program enhancements were developed primarily by agricultural field staff in the Rappahannock basin. They provide specific recommendations on how the state's agricultural BMP cost-share program could be improved to increase BMP implementation. This list will be next brought before a wider audience of farming stakeholders and agricultural organizations to explore whether any other available program changes could further increase annual rates of BMP implementation in the Rappahannock River basin.

The following list of recommended changes has been reviewed by a number of state staff at the Department of Conservation and Recreation. However, further consideration may be needed before individual recommendations are made final.

- Provide cost share for Sidedress Application of Nitrogen on Corn and Late Winter Application of Nitrogen on Small Grains for farmers who are implementing a certified nutrient management plan.
- Provide cost share for Nutrient Management Plan Writing, to include the use of imported poultry litter.
- Provide cost share for soil testing in support of development, revision and implementation of nutrient management plans.
- Provide tax credit incentive for hay bale unrollers to more adequately distribute livestock feeding.
- Provide cost share for litter storage facilities on farms receiving imported litter. (Pad and tarp)
- Provide a per acre incentive payment for precision farming, variable N&P rates, for corn based on soil type/expected yield, grid sampling and soil test levels.
- Cost-share for improvement of existing pasture land for farmers who develop and implement a rotational grazing plan. The plan would include soil testing, proper fertility rates, grazing management techniques, fencing, alternative watering and stocking rates etc.
- Cost-share on tissue testing in support of a nutrient management plan.
- Develop and cost share on BMPs targeted for horse owners who need assistance with pasture management, waste storage and composting.

- Cost-share on no-till small grain/continuous no-till in support of a conservation plan. Offer a $25/acre incentive payment to keep the continuous no-till system in place for five years.
- Provide cost share for surface water impoundments, including impoundments used for irrigation.
- Provide 100% cost share for streambank protection and restoration.
- Provide cost share at $10 per acre for planting small grain that will be harvested (this crop contributes to erosion control and a certain amount of nutrient capture during the winter when potential for leaching and runoff is highest). This BMP must comply with VA Nutrient Management Standards and Criteria and be contained within a certified Nutrient Management Plan to qualify for cost share.
- Investigate and possibly add in accordance with a nutrient management plan an innovative BMP cattle feeding/waste storage facility (patterned after Maryland)
- Expand the Conservation Tillage Equipment Tax Credit criteria from only no-till planters and drills to include newer technology no-till equipment such as subsoilers, para tills and other equipment that leaves residue on the ground for no-till planting.

Other Recommendations

- Locate and account for any best management practices that have been installed in the basin but have not been tracked through the state's tracking program.
- Develop and fund a 75% cost share program or low interest loan program for streambank stabilization and riparian buffers for non-agricultural lands.
- Reduce or eliminate the $100.00 fee for NRCS, VCE and SWCD employees to become certified or recertified under the Nutrient Management Certified Planner Program.
- Provide a tax credit for landowners that implement Farm-A-Syst recommended BMPs
- Increase training opportunities for SWCD staff responsible for administering the cost share and tax credit programs.
- Ensure that sediment reductions remain a key issue throughout implementation.

Outreach and Education ($30,000/year)

- Develop an educational and marketing program about the value of underutilized but highly effective BMPs such as grass filter strips, cover crops, stream fencing, riparian buffers, and livestock loafing lot management.
- Provide signs for landowners to place in field near roadways to promote the use of BMPs.
- Provide funding for educational field days for both farmers and non-farmers, and to develop water quality education programs for adult and youth audiences.

Urban/Suburban Nonpoint Source Recommendations

Introduction to Urban/Suburban Nonpoint Source Management Practices

Urban and suburban nonpoint source management practices (known as urban BMPs) have not yet been assessed through the *Strategy* process for the specific level of implementation, and reductions, that could be achieved in the basin. Therefore, this section includes an extensive discussion of urban BMPs to provide background information for future considerations.

There are two main types of urban BMPs, structural and nonstructural. Structural BMPs are physical structures such as silt fences and sediment traps placed around construction sites to capture sediment before it reaches streams and lakes. These also include stormwater quality management facilities such as ponds, grassed swales with check dams, and other systems designed to trap nutrients, metals, hydrocarbons and other urban pollutants. Structures like these usually contain, rather than prevent, nonpoint source pollution. Structural BMPs also offer communities many other benefits such as flood control and the protection of stream channels.

Nonstructural BMPs, such as land use ordinances and community education programs, are usually designed to prevent or minimize nonpoint source pollution at its source. These BMPs have strong potential for reducing nutrient and sediment loads in the Rappahannock basin.

A Process for Continued Study of Urban/Suburban Opportunities

There is strong interest among Rappahannock basin stakeholders in equitably achieving *Strategy* goals and investigating all available opportunities. Initiatives are already underway in several localities in the region that should reduce nutrient and sediment loads, and that may serve as models for other localities. The Rappahannock River Basin Commission and the Rappahannock Technical Committee have addressed this issue and recognize that reduction opportunities are available through urban nonpoint source programs, and that these opportunities warrant further consideration in partnership with Rappahannock basin local governments.

An Urban Nonpoint Source Subcommittee of the Rappahannock Technical Committee has been formed and charged with the role of working with local officials in the basin to assess opportunities for urban nonpoint BMP implementation. Also, an inventory of stormwater ordinances in each locality has been conducted by the Department of Conservation and Recreation. Results of that survey indicate there are a number of opportunities to improve stormwater management programs across the basin. These results will be used to help establish priorities for developing stormwater management programs and implementing BMPs.

Implementing local water quality ordinances will mostly help address the challenge of maintaining nonpoint source pollution reductions once those reductions are achieved because these ordinances reduce pollutant loads from new development. However, these ordinances (adopted pursuant to the Virginia Stormwater Management Law) also provide for establishment of regional and/or retrofit programs which can address runoff from existing developed areas, thereby helping to meet the nutrient and sediment reduction goals in the first place.

Any urban BMP practices identified through this process, and included in revisions to the *Strategy*, are eligible for cost-share funding under Virginia's Water Quality Improvement Act. This is an area where innovative ideas and creative management approaches will be particularly welcome. It will be most important to identify programs and practices that are not perceived as having an impact on necessary growth and development across the Rappahannock basin.

Water Quality Problems from Urban Nonpoint Source Pollution

The conversion of land from undeveloped open and woodland space to an urban setting, complete with housing, businesses and roads, causes a significant change in the surface runoff hydrology by eliminating opportunities for infiltration and flow attenuation. During the construction process excess runoff can become laden with sediment and nutrients which are then deposited in downstream channels and streams. Post construction, or developed, conditions can increase runoff, accelerate erosion of stream channel bed and banks, deposit additional sediment and nutrients in downstream areas and destroy valuable stream habitats in the stream channel.

The urbanized landscape also collects and stores various urban pollutants such as sediments, nutrients, oils and grease from roads and automobile service facilities, pesticides, herbicides, and fertilizers from lawns and other managed pervious areas, bacterial contaminants and other pathogens from animal wastes and residential on-site sewage disposal systems, and heavy metals from industrial sites. These pollutants are stored on the urban landscape surface and are quickly and easily flushed from impervious surfaces during storm events resulting in potentially high concentrations of pollutant laden runoff. This runoff travels into and through local streams, rivers and lakes, significantly degrading the water quality and aquatic ecosystems.

A typical city block can generate 9 times more runoff than a woodland area of the same size. Heavily fertilized areas such as golf courses, lawns and parks, introduce a large amount of nutrients. Depending on land use, runoff from these areas can also contain a high concentration of sediments and suspended solids. Other toxins and bacteria and nutrients attach to suspended solid and are transported into the waterways during storm events.

Table 8. Urban Nonpoint Source Impacts in Virginia's Tributary Basins*

Flooding – Damage to public and private property, including infrastructure; public safety
Eroded Stream banks – Sediment clogs waterways, fills lakes, reservoirs; loss of property
Widened Stream Channels – Loss of property

****Adapted from the Nonstructural Urban BMP Handbook, Northern Virginia Planning District Commission, 1996***

Urban stormwater pollution makes a large contribution to the overall degradation of our nation's waters. According to the EPA report Environmental Impacts of Stormwater Discharges (1992), urban runoff accounts for an estimated 18% of impaired river miles, 34% of impaired lake acres, and 62% of impaired estuary square miles.

Challenge of Addressing Urban Nonpoint Source Pollution

Urban nonpoint source pollution is difficult to deal with due to a number of factors. First, the urban landscape consists of several different land uses such as residential (high density apartments, townhouses, and detached single family units, as well as the more rural large lot subdivisions), commercial, industrial and roads. These land uses may represent a wide variety of urban pollutants, making it more difficult to effectively capturing and remove these pollutants. As the drainage areas get larger, the options for effective pollutant removal get fewer.

Another factor is the large volume of runoff created by urban impervious surfaces. Most stormwater quality ordinances deal with the “first flush” volume of runoff which usually includes the highest concentration of pollutants. This usually results in the remaining volume of runoff (after the first flush) being bypassed around the system possibly causing stream channel erosion downstream. The placement of volume-control BMPs, such as detention basins, can prove difficult in an urban setting due to available space and the high cost of urban property. A comprehensive approach to these concerns should consider the presence of a floodplain ordinance to help minimize the need for large storm detention. Urban areas that have effectively limited development in the floodplain areas will have less need for large detention facilities.

Structural BMPs for Managing Flow, Volume and Pollutant Impacts of Stormwater

Urban BMPs are an attempt to reduce the impacts of land development on downstream channels and water bodies. Land development decreases the amount of natural water storage by replacing vegetative cover, soils and natural surface depressions with impervious surfaces. This increases the volume and rate of stormwater runoff and changes stream flow characteristics. The common response to this is to construct detention basins. However, detention basins only regulate the rate of flow and not volume. In fact, detention basins can actually create problems by increasing the duration of the peak flow in the channel, increasing the chances of erosion of the channel bed and banks. Once this process begins, it is difficult to stop. Most of the erosion is caused by the rapid flushing of urban stormwater runoff down the natural drainage channels which were formed in times of fewer and much lower peak flows. Eroding stream bed and banks represent a large portion of the urban sediment load which reaches the Rappahannock River.

The science of stormwater management has evolved greatly from the simple detention basin as the cure for urban impacts on stream systems. Of the many types of urban stormwater BMPs, some are better suited for regional stormwater management, such as retention or wet ponds, while others are more suited for on-site stormwater management, such as infiltration and bioretention. Urban BMPs also have different goals (water quality, stream channel erosion, flooding, groundwater recharge, etc.), associated costs, and land space requirements. The Virginia Stormwater Management Handbook (1999) provides a Definition, Purpose, Condition Where Practice Applies, Planning Considerations, and Design Criteria for each BMP. In addition, the Handbook provides Design and Plan Review Checklists, Construction Inspection and As-built Survey Checklists, and Maintenance and Inspection Checklists for each type of BMP. Reference should be made to identify the appropriate goals, space requirements, and target pollutant removal capabilities as applied to each situation.

Discussed below are three example BMPs that may be used for stormwater management purposes in a variety of situations. The purposes and considerations for these types of BMPs are further discussed in the Stormwater Management Handbook.

Bio-Retention

Bio-Retention is a filtering system that allows nutrients from runoff to be absorbed through plant materials such as shrubs or trees while the runoff infiltrates into the soil layers. Bioretention focuses on water quality improvement, provides some control of streambank erosion and flooding, helps replenish groundwater, and adds aesthetic value to an area. Bioretention is suitable for residential to commercial development.

Wet Ponds

Wet ponds are stormwater ponds with a permanent pool of water. They are also known as retention ponds. They improve long-term water quality by capturing sediment and nutrients, and help in controlling stream channel erosion and flooding by reducing peak flows. This BMP can add aesthetic qualities to an area. However, an uncontrolled increase in the number of dams within a watershed can be detrimental. Therefore, the wet ponds should be coordinated with regional or watershed plans for managing stormwater runoff, if available.

Sand Filters

Sand filters are primarily used for water quality control by removal of nutrients and toxins. They are usually underground in ultra-urban areas where the value of real estate is high. Sand filters pose no threat to public safety because they are underground. They are reliable and effective in managing stormwater quality.

The two tables on the following page describe potential benefits of BMPs available for stormwater management. Table 9 lists the functional goals of stormwater management BMPs, and Table 10 provides a more specific description of the levels of water quality benefits (pollutant reduction) that popular urban BMPs provide. The figures in these tables represent only planning-level estimates and should be carefully reviewed in application to a specific site.

Table 9. Functional Goals of Stormwater Management BMPs

STORMWATER BMP	WATER QUALITY	STREAM CHANNEL EROSION	FLOODING
Vegetated Filter Strip	X ++		
Grassed Swale (w/check dams)	X ++	X	
Constructed Wetlands	X ++	X	
Extended Detention	X +	X++	X
Extended Detention Enhancement	X ++	X +	X
Bioretention	X ++		
Retention Basin	X ++	X +	X
Sand Filter	X ++		
Infiltration	X ++		
Infiltration Basin	X	X	X

Detention		X +	X ++
Manufactured BMPs	X ++		
Dry Wells	X++	X++	
Roof Top Storage	X++	X++	
Rain Barrels		X++	
Swales	X++	X++	X++
Reduce Imperviousness		X++	
Strategic Clearing/Grading	X++	X++	
Engineered Landscapes	X++	X++	
Eliminate Curb and Gutter	X++	X++	

Legend: X ++ = Primary functional goal
X + = Potential secondary functional goal
X = Potential secondary functional goal with design modification or additional storage

Table 10. Comparative Pollutant Removal Capability of Four BMP Options

POLLUTANT	POND SYSTEMS	WETLAND SYSTEMS	INFILTRATION SYSTEMS	FILTER SYSTEMS
Sediment	**Excellent**	**Excellent**	**Excellent**	**Excellent**
Phosphorus	High	High	Excellent	Fair-High
Nitrogen	Fair	Fair	High	Fair
Soluble Nutrients	High	Fair	High	Low
Bacteria	Low-High	?	?	Low-Fair
Hydrocarbons	High	High	?	Excellent
Trace Metals	Fair	Fair-Excellent	High	Fair-Excellent
Key: Low = 0-25% Fair = 26-50% High = 51-75% Excellent = 76% or higher				

As this data shows, the use of stormwater management BMPs can significantly reduce nutrients, sediments and a variety of other pollutants entering Rappahannock River. One way to accomplish the implementation of urban BMPs is the adoption of a Stormwater Management (SWM) Program by localities. The recent amendments to the State SWM Program offer localities great flexibility in planning for stormwater management, and have made the adoption of a local program simple and inexpensive.

Water Quality Improvement Funds offer a number of opportunities for developing local stormwater management programs. Grants could assist in the development of local ordinances, installation of retrofit stormwater systems in developed areas, enhancement of stormwater management design manuals to include innovative stormwater BMPs, and the possible hiring of technical staff to assist in the implementation and inspection of stormwater facilities.

Another avenue that could be explored is the use of WQIA funding to support a stormwater water quality cost-share program similar to the agricultural BMP program. Such a stormwater program would focus on current stormwater quality problems from older urban developments and subdivisions. This would help local governments overcome financial problems with such needed improvements. With increased funding to SWCDs through Water Quality Improvement funds, SWCD staff may be available in certain areas to provide technical support in the implementation of such a program.

Nonstructural BMPs for Managing Pollutant Impacts of Stormwater

<u>Low Impact Development</u>

While traditional urban BMPs manage stormwater, they do not replicate the natural hydrology of the watershed, and they can have high maintenance costs. Low impact development designs mimic the natural hydrology of an area by reducing imperviousness, maintaining natural drainage ways and uniformly dispersing runoff across the landscape. Low impact development programs can be structured in such a way as to provide economic incentives to developers for saving natural areas and reducing stormwater and roadway infrastructure costs.

Planning for land development before it occurs not only minimizes environmental impacts, but can also reduce the number and size of the structural measures needed. New developments can maintain the volume of runoff at predevelopment levels by using effective combinations of structural controls and pollution prevention strategies. Management plans can be designed to protect sensitive ecological areas, minimize land disturbances, retain natural vegetation and drainage and capture potential pollutant loads.

One of the best ways of achieving these objectives is encouraging developers to be innovative. Developers throughout Virginia have had success creating projects that minimize impacts on water quality; and a number of these developers have effectively marketed these projects as “environmentally friendly.”

There are several types of local programs that can promote the use of nonstructural methods for controlling and/or improving storm water runoff:

Zoning – cluster development, down-zoning, conditional zoning

- Overlay zoning
- Open space preservation – easements, buffer zones
- Lawn care/nutrient management plans
- Public education

Public education is vital in addressing stormwater issues and building support for local actions to reduce urban nonpoint source pollution. Keeping the public aware of their effect on the watershed in which they live can assist in changing their perspectives on improving water quality. Many educational programs exist through Soil and Water Districts, non-profit interest groups and citizen advisory groups. These programs may include a wide variety of activities including educational conferences, water quality monitoring, stream clean ups, dissemination of educational brochures and newsletters.

Urban Nutrient Management Programs

A significant source of NPS pollution is a result of proper care and management of landscape from residential neighborhoods, golf course and other turf intensive businesses and public institutions. Studies have shown that residential landowners apply fertilizer to their lawns at a much greater rate, per acre, than farmers do to their fields. One of the most promising opportunities for increasing nitrogen reductions in the Rappahannock River basin is the implementation of urban nutrient management programs. These programs are well suited to the Rappahannock basin because of the strong interest and concerns that citizens in that region have for water quality protection and the health of the Rappahannock River.

Urban nutrient management programs are primarily educational, designed to inform homeowners managers of the potential impacts of over-fertilizing residential lawns or golf courses. These programs provide improved information on levels, rates and timing of fertilizer that result in healthy lawns, better uptake of nutrients by lawns and reduced transport of nitrogen. Implementation of these programs also provides a number of ancillary benefits, such as educating citizens of the causes of water quality problems and letting farmers know that they are not the only landowners involved in water quality improvement.

It is recommended that a determined, small percentage of Water Quality Improvement Act funds be allocated for educational and promotional efforts such as urban nutrient management. A reasonable percentage might be 3-5% of the total nonpoint source allotment, for the Rappahannock basin, divided among specific education projects and the educational elements of on-the-ground implementation projects (with an individual project limit). This approach to water quality improvement is sound conservation business; because the nitrogen reduction goal for the Rappahannock River will not easily be achieved until a larger segment of the population learns how to translate their concern for water quality protection into effective solutions.

Future Growth and Development in the Rappahannock Basin

Managing urban and suburban pollutant problems in the Rappahannock basin is not only important in helping meet our Strategy goals; it will also be important in helping to maintain these goals, once they are achieved. It is estimated that the population of the Rappahannock River Basin may grow as much as 16% in the next 12 years. Most of this growth is expected to take place in Fredericksburg, Stafford, Spotsylvania, Middlesex and Lancaster Counties. But, the upper Basin is also experiencing its share of growth. This population growth brings increased nutrient, sediment and toxin loads from parking lots, commercial sites, lawns, pets and poorly functioning septic systems.

Septic Tank Location, Maintenance and Replacement Recommendations

Citizens and local officials throughout the Rappahannock basin support septic tank location and maintenance, and the replacement or repair of known failing systems, as effective ways to improve local water quality as well as reduce nitrogen loads. In particular, the Middle Peninsula Nutrient Reduction Task Force identified this option as a valuable water quality tool in their region. While more study needs to be done of the nitrogen reductions associated with these projects, they are valuable solutions in many cases.

The control of nutrient and pathogen loads to surface waters can begin with proper design, installation, and operation of onsite disposal systems (OSDSs). These systems should be situated away from open waters and sensitive resources such as wetlands and floodplains. They should also be inspected, pumped out, and repaired at regular time intervals. Household maintenance of septic systems can play a large role in preventing excessive system discharges.

BMPs include:
Septic pumping;
Septic tank replacement or repair;
Septic connections - The connection of failing septic systems to sewer lines; and
Septic denitrification - The installation of new systems or retrofitting of existing systems with technology to remove nitrogen from individual systems.

Educational Program Recommendations

Support and cooperation of the general public, local officials and various clubs, organizations, and groups is essential for the success of the *Strategy*. A host of opportunities for active involvement by these citizens will be identified as the *Strategy* is implemented. This element will help foster an understanding and sense of responsibility for water quality management and will hopefully result in management decisions that will reduce current nonpoint source pollution loading and protect waters from the threat of future nonpoint impacts.

Public information and education is most beneficial when citizens see a concerted effort by conservation groups, state and local governments, point sources and others to address nonpoint source pollution and water quality protection. Cooperative efforts among state agencies and local governments enhance opportunities for getting the message to the public and increasing involvement in the Rappahannock restoration effort.

One of the ways in which public education campaigns can be most effective is in showing citizens the ways in which their ordinary, everyday activities can hurt, or help, water quality (such as washing your car on the street). Before people choose the best courses of action to protect water quality, they need to be informed of the issue and understand it. That is why it is important to establish and fund public education and awareness programs.

Types of Public Education Programs include:

- General Public Education and Awareness of water Quality issues;
- Community Involvement/Participation Plan;
- Storm drain stenciling;
- Information on domestic animal waste control;
- Information on household and home maintenance;
- Information on automotive practices;
- Lawn and garden care education;
- Training citizens in water quality or watershed monitoring

It is envisioned that a Community Involvement Action plan or citizen participation program will be developed for the *Strategy*. An initial goal of this effort will be to reach agreement on a consistent message, or set of messages, that will drive the public education effort in the Rappahannock basin. The final plan will include such things as: getting the message of Rappahannock restoration across to others; individual actions that can improve water quality; creating watershed awareness; understanding local water quality issues; identifying needed water quality projects; working with landowners to solve problems; and finding sources of funding.

Storm Drain Stenciling – The primary objective is to educate the public about the dangers of dumping anything into a storm drain in order to prevent pollution. Many residents are not aware that stormwater does not drain to a local wastewater treatment facility. Stenciling programs can discourage people from dumping trash directly into storm sewer systems.

Domestic Animal Waste Control - The primary objective is to educate the public about animal waste controls and what to do with animal wastes.

Household and Home Maintenance Education – Objectives are to identify activities responsible for NPS pollution and alternative actions or solutions.

Automotive Education - Objectives are to identify NPS pollutant problems, identify activities responsible for pollution and identify alternative actions or solutions.

Lawn and Garden Care Education - Addresses best management practices for both residents and lawn care companies. Major objective is to address NPS pollutants, resulting from improper application rates, such as pesticides and fertilizers.

Water Quality and Watershed Monitoring - Helps people learn to assess levels of degradation of local streams and waterways. Also trains people to help find effective solutions to any identified water quality problems.

Related Program Recommendations

Virginia's Oyster Heritage Program

The cooperative effort between the Virginia Marine Resources Commission and Virginia Department of Environmental Quality to expand the development of oyster reefs is an initiative that holds great promise for water quality and living resource restoration in the Rappahannock River and Northern Neck coastal waterways.

Recently, populations of oysters were discovered in the mouth of the Rappahannock River that demonstrate resistance to the two major oyster diseases, Dermo and MSX, that have decimated oyster stocks throughout Chesapeake Bay. Oysters from this area have been found to be up to six years old. The Oyster Heritage Program will expand the area of oyster reefs that have been created in this area in hopes that these disease resistant populations will serve as seed stock to repopulate other areas of Chesapeake Bay.

Many scientists theorize that restoring a healthy and abundant oyster population is one of the most effective "positive feedback mechanisms" that could affect the waters of Chesapeake Bay and its tributaries. As oysters returned, the combined filtering action of their natural feeding process would bring about water quality improvements that would then promote further restoration of living resources.

Virginia's Conservation Reserve Enhancement Program

As discussed within the *Strategy*, implementation of the riparian forest buffer and wetlands restoration components of the Conservation Reserve Enhancement Program is a critical element of achieving the *Strategy* goals of minimizing chronic erosion and stream bank instability in the Rappahannock basin. In addition, this effort is an important part of the nutrient and sediment reductions needed to achieve basin reduction goals.

Therefore, an important part of further *Strategy* planning will be to help ensure that all identified needs for effective CREP implementation are met. In particular, an important element of *Strategy* educational efforts will be to ensure that citizens and landowners are aware of the opportunities for cost-share funding, tax credits and easement payments that will be available for riparian forest buffer and wetlands restoration under CREP.

Local Groups for Watershed Protection and Stream Monitoring

Local watershed groups and community organizations provide one of the best avenues for addressing water quality problems and enhancing BMP implementation in the Rappahannock basin. A number of such groups already exist in the basin (see Appendix B); and opportunities for expansion are available in many areas. The work of these groups is very important to the success of Rappahannock River restoration and are an important part of the Strategy.

TMDL Regulatory Program

Establishing TMDLs for Impaired Waters

Fourteen stream segments in the Rappahannock basin were identified as Impaired Waters within Virginia's most recent (1998) Draft 303(D) Total Maximum Daily Load Priority List and Report. Under this program, total maximum daily load limits of the impacting pollutants will be established for each of these waters; and implementation plans will be developed to achieve these limits. This initiative will be coordinated with Virginia's *Strategy* effort; and the planning and implementation components of these two programs will be managed in a way that will most cost-effectively target potential load reductions.

Recent Action by Environmental Protection Agency to List Bay and Tidal Rivers

Currently, the U.S. Environmental Protection Agency is proposing to address nutrient discharges in much of Virginia's portion of the Chesapeake Bay, including the Rappahannock basin, through a TMDL (Total Maximum Daily Load) regulatory program. It is anticipated that implementation of this program could delay implementation of nutrient removal technologies by the cooperating point source facilities in the Rappahannock basin because of the need to wait to determine what their permit limits would be, before they spend millions of dollar on the installation of a particular system.

The majority of participants in the *Strategy* process strongly opposed overlaying a regulatory approach on top of the cooperative *Strategy* effort for addressing nutrient and sediment problems in the Rappahannock basin. Regulatory programs often fail in the task of implementing the most cost-effective solutions to pollutant reduction. They also fail to engender personal responsibility and commitment to protecting water quality; and such commitment is the only approach that will make Rappahannock restoration successful in the long run.

Strategy participants currently plan to proceed with their own approach to restoring Rappahannock River and to monitor the potential development of any regulatory program. In particular, the effect that such a program would have on nutrient and sediment reduction goals will be closely monitored. Many participants feel that the various levels of government have the responsibility to coordinate the *Strategy* program with the TMDL program to avoid regulation and to ensure that efficiency and consistency are applied to implementation actions.

Development of a Rappahannock Strategy Technical Appendix

Since the publication of the *Rappahannock Strategy Status Report* in July of 1998, a substantial portion of background technical information on regional nutrient/sediment loads and water quality trends in the Rappahannock River and Northern Neck Coastal basins has been trimmed from the *Strategy* document. In response to the "Final Public Comment Draft" of the *Strategy*, published in September of 1999, the only comment that was received was that some of this supporting information needs to be included in the *Strategy*, or in a related *Strategy* document. In particular, these commenters noted that the final *Strategy* needs to present the baseline, and rationale, for the inception of the *Strategy* initiative in the Rappahannock basin.

In response to this feedback, a document will be produced in early 2000 that details much of the technical information, including loadings, water quality trends and model results, which underpin the *Rappahannock River and Northern Neck Coastal Basins Tributary Restoration Strategy*. This document will include the results of a Chesapeake Bay Program Watershed Model run, to be conducted in December of 1999, that will provide improved (better resolution) and up-to-date nutrient and sediment loadings information for the basin. Also, this document will reflect up-to-date information on living resource status and trends.

In addition, it has been noted that further refinements may need to be made with regard to implementation efforts outlined within the *Strategy*. The Departments of Environmental Quality and Conservation and Recreation have had three years of experience implementing the grants cost-share program under the Water Quality Improvement Act for point source and nonpoint source conservation practices. However, there still may remain a number of opportunities for improving other components of *Strategy* implementation. As needed, documents, pamphlets and/or brochures will be produced that will assist and promote implementation.

Development of a Rappahannock Basin Water Management Plan

The local and state elected officials on the Rappahannock River Basin Commission have considered the need to develop a Water Management Plan for the Rappahannock River basin. This Plan would address certain issues that are not part of the *Rappahannock Strategy* effort, nor of the planning efforts that will be undertaken with respect to the TMDL program. However, these local and state officials recognize that there are a number of relationships between water quality issues and water quantity issues in the Rappahannock basin; and that these issues must be considered in a comprehensive manner.

Strategy Monitoring and Tracking Recommendations

Finally, an important need is to improve monitoring and tracking of the water quality and living resource responses that will be brought about through the implementation of the *Rappahannock Strategy*. Although the Rappahannock River basin has an extensive and well-designed monitoring program, this program was not specifically developed to address the types and locations of water quality improvements that will result from Strategy implementation. The improvements to the monitoring program that *Strategy* participants cited as being most valuable include:

- Improve monitoring of "bedload" sediment levels.
- Improve monitoring of dissolved oxygen levels in lower Rappahannock River.
- Improve monitoring and analysis of water quality conditions in the western portion of the Rappahannock basin.
- Improve monitoring and analysis of water quality conditions in Great Wicomico River and Northern Neck coastal creeks.

Participants in the *Rappahannock Strategy* process made strong commitments to goal-setting and implementation based on benefits to water quality and living resources that were projected by the Chesapeake Bay water quality computer model. However, these participants have noted that it will be important for them to witness actual improvements in the Rappahannock system as they go through the implementation phase of the next decade.

In particular, as participants endeavor over the coming years to involve more farmers, local officials and others in the initiative to restore Rappahannock River, it will be critical to be able to provide these people with information on how water quality and living resources have already responded to nutrient and sediment reductions. These efforts will be most successful if citizens in the basin see the fruit of actions they have already undertaken.

A group of agency staff and citizen monitors will be formed during the spring of 2000 to consider needs and opportunities for improved water quality tracking. In addition, agency staff will continue to address the issue of tracking voluntary implementation of agricultural and urban/suburban BMPs across the basin so that credit can be given for these important conservation actions.

VIII. Follow-up and Reevaluations

To ensure that the *Rappahannock Tributary Restoration Strategy* remains up-to-date and effective, it was determined through the *Strategy* process that at least two reevaluations will be conducted between the development of the *Strategy* and the goal year of 2010. These reevaluations will also be used to incorporate information and decisions developed through the continued planning processes outlined in the previous chapter. In addition, milestones will be established, and progress toward those milestones will be assessed annualy.

These reevaluations were supported unanimously by RTC members, including conservation groups, local government staff, agricultural representatives, treatment plant operators, agency staff, scientists and others. Members of RTC felt that the reevaluations in this package will help promote a dynamic and responsive *Strategy*. In particular, RTC members felt that there are a number of unpredictable factors inherent in the *Strategy* planning process that require monitoring and reassessment. These include: current differences between levels of nutrient and sediment reductions estimated by the Chesapeake Bay water quality model and those estimated through water quality monitoring (monitoring data indicate higher reductions achieved since 1985); effects of annual rainfall levels and storm events on river health; lag time for nutrient reductions; response time for water quality indicators and living resources; and effects of anticipated high rates of growth and development in the Rappahannock River basin.

All reevaluations will be conducted and recommended in partnership with stakeholders, local government and interested parties in the basin.

2002 Program Reevaluation

A program evaluation will be conducted in 2002, the results of which will be provided to the General Assembly in the November, 2002 Annual Tributary Strategies Report. The purpose of this evaluation will be to ensure that program changes and enhancements, necessary for achieving nutrient and sediment reduction goals, have been made and are in place. In addition, this program evaluation will consider all additional opportunities for programs and/or funding that would close any remaining gap between ongoing efforts and achievement of the BNR-BNR Equivalent nitrogen goal by the year 2010. Examples of specific items to be considered through this reevaluation include:

- Determine whether recommended program changes have been put in place that will achieve the management practices identified in the *Strategy*.
- Continue to assess ways to improve procedures and eligibility for agricultural cost-share.
- Identify any barriers to effective implementation, and recommend solutions.
- Identify ways to expand public involvement in the Rappahannock restoration effort.
- Identify other programs, practices and opportunities for achieving and enhancing sediment and nutrient (particularly nitrogen) reductions.
- Evaluate effects of other programs (including TMDL) on the *Strategy* effort.
- Evaluate sufficiency of funding mechanisms for continued implementation.

This reevaluation is really for the purpose of ensuring that governments and agencies have done their job providing the citizens in the Rappahannock basin with the tools necessary to achieve *Strategy* goals. As such, this reevaluation will be principally conducted by interested stakeholders in the basin, particularly agricultural representatives. Agency staff and other resource staff will provide technical and programmatic information to assist this reevaluation.

2005 Technical Reevaluation

A technical evaluation will be conducted in 2005. The purposes of this evaluation will be to: assess progress toward nutrient and sediment reduction goals; evaluate the sufficiency of water quality monitoring to track *Strategy* implementation (including monitoring in the western Rappahannock basin and Northern Neck coastal waterways); measure the response rate of water quality in the Rappahannock River to these reductions; assess the recovery of living resources; identify new technologies that would promote this recovery; evaluate any new developments to the Chesapeake Bay water quality model; coordinate monitoring/modeling activities and data; identify ways to accelerate nutrient and sediment reductions, CREP implementation and delisting of Impaired Waters; and revise the nitrogen goal or deadline if determined to be unattainable.

One of the major issues that will have to be addressed through the 2005 *Strategy* reevaluation, though it is more programmatic in nature, will be ways to sustain and increase the rate of agricultural BMP implementation by farmers in the Rappahannock basin between the years 2005, 2010 and beyond. In order to meet the *Strategy* nitrogen reduction goals, additional opportunities for reductions will have to be identified; and ways to involve the large majority of farmers in the basin in implementing needed BMPs will have to be found.

As noted above, the results of all reevaluations, and necessary amendments to the *Strategy*, will be conducted through the Secretary of Natural Resources' Annual Report to the General Assembly on the Development and Implementation of Tributary Strategies. This will ensure that the program remains responsive and that elected officials remain apprised of the needs and changes of the *Rappahannock Strategy* effort.

Appendix A

1999 Amendments to Virginia's

Tributary Strategy Law

Appendix B

Rappahannock River Basin

Conservation Groups and

Community Watershed Organizations

Appendix C

Glossary of Select Terms